The Pelagic Complex in the North East Atlantic Ocean

Challenges and possibilities in the pelagic sector
– looking towards the future

International Conference 7–9 September 2010

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TemaNord 2011:531

ISBN 978-92-893-2228-7

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Print: Kailow Express ApS

Copies: 230

Cover: Astrid Andreassen

Photo: Ingram; Karin Beate Nøsterud; Johannes Jansson; bee-Line; Photodisc

Printed in Denmark

This publication has been published with financial support by the Nordic Council of Ministers. But the contents of this publication do not necessarily reflect the views, policies or recommendations of the Nordic Council of Ministers.

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Preface

The Pelagic Complex conference was the major event in the Faroese Chairmanship of the Nordic Fisheries Cooperation 2010. It proved to be an excellent conclusion to the year-long discussion on highly-topical and extremely relevant fisheries policy issues that the Faroese Chairmanship had desired to address in 2010.

It was my distinct pleasure and honour to open the conference and to participate actively in many of the sessions. Personally, I found the conference extremely re-warding and highly relevant to the many issues I face daily as a minister.

This report on the proceedings of the conference presents an overview of the numerous speeches and discussions that comprised the conference. The Faroese Chairmanship has compiled the conclusions and recommendations of that conference, which I for one will strive to have included in the future work of the Ministry on the sustainable development of the pelagic fisheries. I warmly encourage my fellow ministers to review and discuss the recommendations presented here in their ongoing strategic discourse on the economic and social development of the fisheries sectors. I intend to offer some of the recommendations presented herein to the Nordic Council of Ministers for their joint review and discussion.

I would like to take this opportunity to thank all of the participants and speakers who helped to create such a memorable and beneficial conference. I especially wish to thank Hjalti í Jákupstovu and his tireless staff for their exemplary work in making the conference a success.

I trust that my colleagues around the world engaged in fisheries policy-making, as well as those in the fishing industry and in the many research communities focused on fisheries management, will find these *Proceedings* beneficial in their ongoing work to ensure a sustainable fisheries.

Jacob Vestergaard
Minister of Fisheries
Government of the Faroe Islands

Introduction

The *Pelagic Complex* conference was held on 7 – 9 September 2010 in the Nordic House Cultural Centre in the Faroe Islands. The theme of the conference was especially relevant for political policymakers in fisheries management and attempted to focus on the specific challenges faced by the scientific community engaged in fisheries research. It brought together over 170 participants from 14 different countries. Some 100 delegates attended from the Faroe Islands, while the others hailed from Norway, Iceland, Denmark, Holland, England, United States, Scotland, Finland, Russia, Canada, France, Greece and Australia.

In 2010, the Faroese Ministry of Fisheries assumed the Chairmanship of the Nordic Fisheries Cooperation, under the auspices of the Nordic Council of Ministers. In the Programme for 2010 envisioned by the Faroese Chairmanship, the conference served as a major focal point in a series of highly-relevant and note-worthy political discussions focusing on the various core areas of Nordic fisheries policy.

The purpose of the conference was to focus on the pelagic stocks in the North East Atlantic Ocean and the fishing industry built on the exploitation of these fishing stocks. It is estimated that these stocks represent a biomass of over 20 million tonnes with an annual landing value of 10 billion DKK and are fished by several hundred fishing vessels from some 8-10 countries.

The conference attempted to draw together current expert knowledge within relevant research fields and to set the stage for practicable dialogue on the important core issues in the future sustainable utilization of pelagic stocks. The conference was divided into six sessions with a total of 32 presentations:

1. Challenges in the pelagic sector: private sector perspectives
2. Changes in the biological and hydrographical relationships for pelagic resources, including climate change
3. Technological challenges for a more profitable pelagic fleet and industry – how to increase value and reduce costs
4. Economics and the management of the pelagic fleet
5. Allocation instruments for international shared stocks
6. Taking stock – the quagmire of allocation

For this *Proceedings*, each Session Chair provided a useful commentary and summary of the current knowledge in each of the session areas. The Conference Chair drafted the conclusions and recommendations and is solely responsible for the conclusions and recommendations presented herein. Other relevant material from the conference is also provided. For example, an appendix contains the opening speech of the Faroese Minister of Fisheries, as well as abstracts of the papers presented and the programme of the conference.

The presentations / papers presented at the conference can be found on the conference website (www.pelagiccomplex.com), together with a brief curriculum vitae for each of the individual speakers.

Sammendrag

Den internationale konference The Pelagic Complex in the North East Atlantic Ocean. Challenges and possibilities in the pelagic sector. Looking towards the future blev afholdt 7-9 september 2010 i Nordens hus på Færøerne. Temaet for konferencen er politisk aktuelt og er også en stor udfordring for de videnskabelige miljøer. Konferencen samlede over 170 deltagere fra 14 lande.

I 2010 har det færøske fiskeriministerium formandskabet i det nordiske fiskerisamarbejde i regi af Nordisk Ministerråd. I programmet for formandskabet var konferencen hovedaktiviteten I en serie af relevante og interessante politiske diskussionen om kerneområder i nordisk fiskeripolitik.

Formålet med konferencen var at sætte fokus på de pelagiske bestande i nordøstlanten og det fiskerierhverv som er bygget på udnyttelsen af disse bestande. Vi har med at gore bestande, som udgør en biomasse på over 20 millioner tons, har en årlig førstehånds landingsværdi på 10 milliarder DKK og omfatter flere hundrede skibe fra 8-10 lande.

Konferencen kom således at redegøre for aktuel viden på relevante forskningsfelt og lægge op til dialog om betydningsfulde temaer, som udgør kernen i fremadrettet bæredygtig udnyttelse af de pelagiske bestande. Konferencen var delt op i 6 sessioner med totalt 32 præsentationer:

1. Challenges in the pelagic sector: private sector perspectives
2. Changes in the biological and hydrographical conditions for pelagic resources, including climate change
3. Technological challenges for a more profitable pelagic fleet and industry – how to increase value and reduce costs.
4. Economics and the management of the pelagic fleet
5. Allocation instruments for international shared stocks
6. Taking stock – the quagmire of allocation

Rapporten indeholder materialet fra konferencen. Den færøske fiskeri-minister satte konferencen og hans åbningstale ligger som bilag. Abstracts fra indlægsholderne ligger også som bilag. Rapporten summerer op den aktuelle kundskab for hver enkel session, skrevet af sessionens formand. Konklusioner og rekommandationer er skrevet af konferencens formandskab og er kommenteret af sessionsformændene. Det er ene og alene formandskabet som står til ansvar for konklusionerne og rekommandationerne.

Præsentationerne på konferencen kan findes på konferencens hjemmeside (www.pelagiccomplex.com) sammen med en kort cv for de enkelte indlægsholdere.

Summary of the sessions

Each session was led by a Session Chair, who, in addition to managing the comments and discussion held during the session, also had the responsibility of preparing a summary of the individual presentations and the subsequent discussion. Each session included a number of presentations followed by focused discussion. Each session also ended with a general discussion on the overall theme of the session.

Session 1. – Challenges in the pelagic sector: private sector perspectives.

The purpose of this session was to get a better understanding of the challenges faced by the private operators in the pelagic fisheries sector. Encompassing a wide geographic overview, the issues discussed covered the entire value chain – from harvesting, to processing and markets.

Key questions posed were:

- *What are the future prospects of the private pelagic fisheries sector?*
- *How should calls for more direct exploitation of pelagic resources (as opposed to fishmeal and fish oil) be addressed?*

Bergur Poulsen, Christian Olesen, Gunnþór Ingvason, Audun Maråk.

Summary by Hjalti í Jákupsstovu

The industry view of the challenges facing the private pelagic fisheries was discussed, based on the perspective and experience from four different countries.

From the Faroes, *Bergur Poulsen* gave a description of the Faroese pelagic fisheries and industries, including the existing fleet, resources and the restrictions placed on them. He very much stressed the fact that alt-

though there was no restriction in place limiting Faroese vessels from selling or landing their catches in any country they wished, there were a number of formal and informal restrictions imposed on non-Faroese vessels landing and selling their catches outside their national ports. This creates a challenge to the local Faroese industry to remain competitive against foreign buyers bidding for Faroese catches and trying to secure permission for non-Faroese fishing vessels to land in the Faroes. He also showed the volume of fishmeal feed used in the aquaculture industry, and stressed that the production of this feed was a sustainable use of the pelagic resource.

Christian Olsen from Denmark described the various species comprising the pelagic complex both in the Norwegian Sea and in the North Sea. He also described the setup of the Danish pelagic producers' organisation and how the pelagic fleet was downsized to fewer and more efficient ships with the introduction of ITQ¹ from 2003. He also described how the industry influenced the management scheme. He referenced the present dispute over the distribution of the pelagic resources and offered some critical remarks of the proposed Icelandic and Faroese national quotas. He advocated for an international (RAC²) forum to settle disputes on equitable distribution where fisheries organisations and other stakeholders could discuss actual issues of import, e.g., official responses to the questions presented by government authorities and others.

Gunnþór Ingvason presented an overview of how the Icelandic pelagic industry was over time rationalised from a high number of small vessels and fishmeal factories into a much lower number of larger, more efficient vessels, while at the same time the number of fishmeal processing plants was consolidated into larger and more efficient plants. He also demonstrated how gradually an ever greater fraction of the Icelandic pelagic landings were used for human consumption through filleting and round freezing. There are several vessels freezing at sea now and freezing and fishmeal factories were also merged. In this way, the offal from filleting

¹ ITO = Individual Transferable Quota

² RAC = Regional Advisory council

and processing for human consumption could be utilized without unnecessary transport.

Finally, Ingvason gave an overview of the state of the pelagic stocks and the future need of the industry for rationalisation and investment. He also stressed the need for the coastal States to come to an agreement and the need of the industry to have a stable framework under which to be organised.

Audun Maråk from Norway divided his presentation into two parts. During the first part of his presentation, he offered some very critical comments on the Icelandic and Faroese standpoints regarding the issue of equitable distribution of the mackerel TAC³ and advocated that the distribution should be based on a longer time period (15 to 20 years) and gave as an example the fact that since 1994 Norway has pointed to the skewed distribution of the mackerel stock relative to the shares between the EU and Norway. Nevertheless, Norway, even though arguing for a larger overall share of the mackerel TAC, has been reasonable in setting a national quota.

In the second part of his presentation, he stressed the need for an ecosystem approach to the management of the pelagic stocks.

³ TAC = Total Allowable Catch

Session 2. – Changes in the biological and hydrographical conditions for pelagic resources, including climate change.

The objective of this session was to provide an up-to-date overview of the state of the pelagic resources in the North East Atlantic Ocean. Often referred to as the “pelagic complex”, the session focused on environmental conditions and their impacts on the distribution and productivity of pelagic species, including the effects of climatic change.

Asta Gudmundsdóttir, Trevor Platt, Hjálmar Hátún, Webjørn Melle, Jens Chr. Holst, Bogi Hansen, Gregory Beugrand, Alexander Krysov.

Summary by Eero Aro

Changes in primary production in the entire North East Atlantic Ocean have been observed in recent years, mainly caused by changes in various environmental parameters. In the Norwegian Sea, for example, an increase in temperature and salinity has been observed since the mid-1990s. The last 6 – 7 years have been notably warmer, both in the Norwegian Sea and in the Barents Sea. Since 2001, there has also been an increase in the flow of warmer water into the Norwegian Sea.

With regard to secondary production, after 1995 there has been much more subtropical influence, as well as much more phytoplankton production. The amount of warm-water zooplankton species has increased, while a lower abundance of the sub-arctic zooplankton species (*Calanus finmarchicus*) has been observed. The timing of the production of *Calanus* is related to the phytoplankton production cycle and delayed production in Arctic water is assumed to be linked to low temperatures. There exists a clear difference and variation in timing between years in primary and secondary production, as well as a delay in seasonal production cycles from coastal water to Atlantic and Arctic water, from southeast to northwest.

It has been concluded that the subpolar gyre regulates, *inter alia*, the marine climate, plankton communities and the stock dynamics of blue whiting. The dramatic decline of the subpolar gyre after 1995 has induced a large ecosystem shift, however, the recent mackerel “outburst” is not a simple response to temperature only.

The environmental changes and the changes in primary and secondary production have no doubt influenced the observed changes in the distribution of pelagic stocks. Stock size has also been linked to changes in the distribution patterns. It has been observed that when the herring stock is at a medium or high stock size, it utilizes the Norwegian Sea as its feeding area. Herring feeding migration, on the other hand, is related to the dynamics of the overwintering *Calanus* population.

There are signs that the Norwegian Sea ecosystem is cyclic, with physical processes as the underlying drivers. Time series data indicate that we are at or just past the peak of the last AMO⁴ cycle (Norwegian Sea cooling since 2007) and food levels are low for many species in the Norwegian Sea at present. Those species remaining in that area show a reduced individual growth rate, but those with migration abilities move to other areas where better feeding conditions exist.

Recent studies show that climate change may strongly alter fish stocks. Changes in climate are recognised to control the spatial distribution of fish. Usually, each species has a unique spatial distribution, which is determined by its bioclimatic niche. Within the specific spatial distribution of a species, overfishing has strongly reduced the fish stocks present. The obvious climate change observed today will modify the spatial distribution of species, and the scale of the impact of climate will depend on the intensity of warming. The impact of climate will be prominent at the edges of the spatial distribution (and bioclimatic niche) of the species. At the southern edge, warming will negatively impact stocks and at the northern edge, it will positively impact the stock.

It has been concluded that the Norwegian Sea can probably only hold a large pelagic complex for a very short period at the top of an ecologic cycle. At the peak of an AMO cycle, the probability for a strong reduction in the pelagic complex is great because of large fish stocks, depleted food resources and generally lowered productivity during the expected AMO downward phase.

Presently (summer 2010), mackerel is distributed over the core area of the Norwegian Sea and south and west of Iceland. Herring is predominant-

⁴ AMO = atlantic Multidecadal Oscillation

ly found in the periphery of the Norwegian Sea and surrounding waters. The blue whiting biomass was very low during the survey in the entire survey area; capelin was observed mainly north of Iceland, and pearlside south west of Iceland.

Session 3. – Technological challenges for a more profitable pelagic fleet and industry – how to increase value and reduce costs.

The objective of this session is to present and discuss the technological challenges facing the pelagic sector both at sea and on shore, and from this to identify future research priorities.

John Willy Valdemarsen, Erik Skontorp Hognes, Leif Roger Gjølseth, Ingve Sørffonn, Ragnar L. Olsen, Ida Aursand, Sigurjón Arason, Henrik Hauch Nielsen.

Summary by Ida Aursand

One of the topics in this session was energy efficient motor systems. As technology advances and different systems are combined, new, energy-efficient solutions for the pelagic fleet can evolve, as, for instance, the combination of LNG⁵ and fuel cells. A holistic approach to the design of engine systems is crucial to get the best result, wherein all the important operations, such as fishing with special gears, for example, are taken into account. The regulation of the fishing fleet is one of the reasons why new technology is often not taken into use.

Another topic in this session was the carbon footprint of pelagic products relative to different markets. Compared to other seafood, such as whitefish and farmed salmon, pelagic fishing is energy efficient. However, there is still room for improvement, especially in the choice of fishing gear and the transport method used to market. The carbon footprint of products has been shown to be a good tool for the industry to trace energy consumption and thereby the relative energy costs in the value chain.

A new procedure for onboard handling of fish has been shown to have positive effects on fish quality. It has also been shown to be more efficient than today's procedures and to need less labour. New grading systems for pelagic fish are under development, and this will give the industry the opportunity to achieve a higher and more uniform fish quality.

⁵ LNG = Liquefied Natural Gas

New measurement techniques for the characterization of raw material quality, such as fat content and risk of belly bursting, were presented. These new techniques afford the industry the opportunity to get objective information about the raw material at an earlier stage in the value chain.

Advanced chilling technology has been shown to yield high product quality, and it was emphasized in the session that the rapid chilling of fish onboard is crucial for achieving high product quality. New concepts and methods are under development, and they should be an important factor in the design of new vessels.

The sustainability of producing feed from fish was discussed. The speaker concluded that as long as a market for food does not exist, it would not be unethical to produce feed from some pelagic species.

The effect of different fishing gears on quality was presented. The T90 cod end was shown to cause less damage to mackerel, compared to traditional trawl, possibly because of the water currents in the gear, which would consequently impact the movement of the fish inside the cod end.

The increased utilization of fish processing “waste” or by-products, now commonly referred to as “rest raw material”, was seen to be an opportunity for the industry, especially for feed production.

The restriction of catch sizes, especially for purse seiners, was mentioned as one of the challenges facing the fleet.

Session 4. – Economics and the management of the pelagic fleet.

Economic considerations in the management of the pelagic fisheries are central to understanding the overall outcomes for the fishing fleet, the fishers themselves and for the general public. Key issues include profitability and how the management framework and related management tools affect the economic outcomes and prospects for profit generation.

Key questions covered included:

- *How can pelagic fisheries be made more profitable? Does the present management arrangement produce economic profit?*
- *In developing a modern fisheries model, what role do social aspects play?*

Max Nielsen, Ragnar Arnason, Bjarni Arnason, Poul Degnbol.

Summary by Sveinn Agnarsson

Session 4 started with the Chairs from Sessions 2 and 3, *Eero Aro* and *Ida Aursand*, respectively, summing up the proceedings of the previous day. Four presentations then followed.

First, *Max Nielssen* of the Institute of Food and Resource Economics, University of Copenhagen, presented the results of the study⁶, *Socio-Economic Return of Pelagic Fisheries in the Northeast Atlantic Ocean*, financed by the Nordic Council of Ministers. The purpose of the study was to identify the socio-economic contribution of a well-managed North East Atlantic Ocean pelagic fisheries, and to identify to whom the returns accrue, as well as to assess redistribution from the industry to society.

In this study, socio-economic return is defined as “the surplus remaining after remuneration of capital and labour in excess of remuneration obtained in other businesses.... [and] after deduction of public net-

⁶ Nielsen, M et al., 2010, Samfundsøkonomisk afkast af pelagiska fiskeri i nordsøatlanten, TemaNord 2010:573 (English Summary: Socio-Economic Return of Pelagic Fisheries in The Northeast Atlantic Ocean, pp 95-99). The report was prepared especially for the conference.

expenses to the fleet segment”. The study compares the performance of five fleets in five different countries. In three of these cases – Iceland, the Faroe Islands and Denmark – the fisheries are managed by an individual transferable quota (ITQ) system. The Norwegian purse seine fleet with blue whiting licences (vessels longer than 27.5 m) is subject to a non-transferable quota system, while the British pelagic fleet (vessels longer than 40 m) is managed by a quota system set up producer organisations.

The study concludes that maximum socio-economic rent returns have already been obtained in Iceland, where resource rent is estimated at 43% of catch value. The Faroe Islands and Denmark could potentially also reach maximum resource rent without changing the management system, but quota trading must be allowed if Norway and the UK are to be enabled to increase the return on their respective fisheries.

Table 1. Size of the socio-economic returns in 2007 before deduction of public expenses for the fishing industry.

	Iceland	Norway	Faroe Islands	Denmark	UK	Total
Million DKK	530	559	213	121	456	1,879
Share of catch value	43 %	28 %	38 %	17 %	32 %	32 %

The study also finds that fishers receive most of the return, with society-at-large only receiving about 10 %. Further redistribution could be made to society without negative effects on efficiency in each of the case study regions, except possibly Iceland.

In his paper, “Lost rents, sunken billions”, *Ragnar Arnason*, Professor of Economics at the University of Iceland, focused on the fact that studies indicate that the world ocean fisheries are currently operated at a huge loss of profit. A recent World Bank/FAO⁷ study indicates that the annual global loss could amount to USD 50 billion. In order to realise the full potential benefit of the global fishing industry, it is necessary to introduce proper institutional management structures, which ideally would consist of some form of property rights, such as IQs, ITQs or TURFs⁸. In the North East Atlantic pelagic fisheries, there are additional problems, based on the

⁷ FAO = Food and Agriculture Organization of United Nation

⁸ TURF = Territorial Use Right in Fisheries

fact that the pelagic fisheries are typically unstable and migratory, and the species are often the low-value prey of much more valuable predators.

Bjarni Arnason, an auditor with P/F Nota in the Faroe Islands, discussed the financing of the Faroese pelagic fleet, which currently numbers nine vessels. Since 1998, the fleet has operated with substantial profit before extraordinary items, although losses were experienced in 1999, 2000, 2004 and 2008. Indeed, the pelagic fleet has outperformed any other fleet segment in recent years, although the factory trawlers have also done well. It should be noted that these two fleets are subject to ITQ systems.

Poul Degnbol, Head of Advisory Programme, ICES⁹, pondered the question whether social aspects have a place in fisheries management. In Degnbol's view, social aspects are explicit or implicit policy drivers, but the main question is how these aspects can be addressed in a transparent and enlightened manner. Authorities could, of course, adopt the ostrich approach and ignore the problem or pay their way out through subsidies. However, differentiated regimes could be promoted where a modern, effective sector is developed, while room is also left for special treatment of a limited part of the sector where there may be a strong case for addressing social concerns. Finally, it could be possible to manage the fisheries in an efficient manner that would provide net surplus for the common good.

Following the presentations, the four presenters joined the Session Chair, Sveinn Agnarsson, Director of the Institute of Economic Studies, University of Iceland, in a panel discussion on the future of the pelagic complex, and the challenges facing the industry.

⁹ ICES = International Council for the Exploration of the Sea

Session 5. – Allocation instruments for international shared stocks.

Joint resources have to be shared by the legitimate partners in a fair and acceptable way. The objective of this session was to present relevant allocation methods and criteria in use today and possible ways forward.

R. Quentin Grafton, A.L. (Andrew) Serdy, Eskild Kirkegaard, Kjartan Høydal, Áslaug Ásgeirsdóttir, Rögnvaldur Hannesson, Torbjørn Trondsen, Hjalti í Jákupsstovu.

Summary by Bjarti Thomsen

This session contained eight presentations. The first five presentations gave examples of existing practices stipulated by various agreements entered into by regional fisheries management organisations (RFMOs) and coastal States. Three presentations followed offering thoughts on possible alternative allocation approaches.

The first presentation by *R. Quentin Grafton*, Professor of Economics at Australian National University, entitled *The economics of allocating resources on trans-boundary stocks* was given as a video lecture, as he could not be present in person. Using the various fisheries for highly migratory tuna as an example, he showed that, although regional fisheries management organisations (RFMOs) had used different approaches, they had all failed to prevent overcapacity and overexploitation. He advocated individual fishing quotas (IFQ) rather than limiting fishing effort and proposed a permanent, country-share of a total allowable catch (TAC) defined by tuna species and area for members of specific RFMOs. The annual allocations generated from the permanent country-shares could be traded to resolve access disputes and encourage innovation in management to provide incentives for better outcomes for all parties.

The presentation by *Andrew Serdy* from the School of Law, University of Southampton in the United Kingdom, entitled *The (lack of) law on allocation of straddling and highly migratory stocks*, started by stating that there are generally no UN-level instruments or conventions on allocation. However, some guidance and instruments can be found in international agreements such as the 1982 United Nations Convention on the Law of the Sea (UNCLOS) and in the 1995 UN Fish Stocks Agreement (UNFSA). With

regard to international agreements, Serdy, as an example, used Iceland's position against ICCAT¹⁰ when they considered starting a tuna fishery in their own waters while the ICCAT Commission, relying mainly on the historical catch principle, was reluctant to allocate any quota to Iceland. Serdy also discussed the fairness and consequences of using historic catch and spatio-temporal criteria together with questions related to the interests of coastal States, new signatories to a convention, as well as the individual concerns of developing countries.

In the presentation entitled, *Coastal state arrangements, Blue Whiting, Herring, Mackerel, Capelin, Eskild Kirkegaard*, principal advisor on fisheries with DTU Aqua, Denmark, gave an overview of the coastal State arrangements regarding the four pelagic species in the North East Atlantic Ocean.

These arrangements are central as a forum in the management of the pelagic fisheries, as they allow TACs to be set and shared between the parties. The TAC is set consistent with a target fishing mortality, defined from single species stock size considerations, which may not be optimal in the case of ecosystem changes. The arrangements have been in place for many years now with only some periods of disruption and negotiation breakdowns.

In the presentation, *NEAFC¹¹ management, Kjartan Hoydal*, Secretary of NEAFC, underlined the importance of RFMOs for sustainable fisheries management in the high seas. The objective of NEAFC is long-term conservation and optimum utilisation of fishery resources. The contracting parties have been able to agree on allocations of pelagic stocks, but breakdowns have occurred with regard to blue whiting 2003-2005, herring 2003-2006, and there is currently no agreement for mackerel in 2010/2011. This shows the 'wicked' problem of allocation.

In the presentation, *The Norway – Iceland experience, Áslaug Ásgeirsdóttir*, Associate Professor of Politics, Bates College, Maine, USA, asked the question "Who gets what?" and offered an answer based on studies of seven management agreements signed by Norway and Iceland, along with other nations, regarding four different straddling stocks during the years 1980-1999. The allocation between States Parties varies across stocks and over time. The

¹⁰ ICCAT = International Convention for the Conservation of Atlantic Tunas

¹¹ NEAFC = North East Atlantic Fisheries Commission

analysis reveals the centrality of politics in the negotiating process and shows how powerful domestic interest groups can influence negotiators and result in a more favourable distributional outcome for that country.

In the presentation entitled, *Is game theory a possible method to solve the allocation problem?* Rögnvaldur Hannesson, Professor, Norwegian School of Economics and Business Administration, Bergen, Norway, showed how game theory or “the theory of strategic interaction” can be useful to reveal requirements for cooperative solutions when sharing fish stocks. For all players to choose a cooperative strategy to maximise the outcome for all parties, each player must achieve more than in a non-cooperative situation. The herring stock shared between Norway, the EU, Iceland, the Faroes and Russia was used to illustrate cooperative and non-cooperative situations. Small-share players may have weaker conservation incentives for a cooperative strategy and it is likely that they must be offered a greater share than corresponds to their rights according to the sharing parameters used.

In the presentation, *A market oriented management (MOM) model for straddling pelagic stocks*, Torbjørn Trondsen, Professor, University of Tromsø, Norway, compared landing values and concluded that Iceland could have doubled its TAC value in 2009, if Norwegian price levels had been obtained. He stressed that quota allocations in fact are allocations of resource rents and argued that the present system with national TAC shares is not optimal in collecting the resource rent. He proposed an auction system where all licensed fishing enterprises from member States could bid for individual quotas. Allocation of individual quota values instead of a national quota share will motivate market-oriented value adding and increase the overall total TAC value.

In the final presentation, entitled *Alternative approaches to sharing*, Hjalte í Jákupsstovu, retired Director of the Faroe Marine Research Institute, Tórshavn, Faroe Islands, used herring as an example and showed changes in the distribution and migration pattern over the past 50 years or so. He gave a list of the allocation principles in UNFSA¹², but concluded that there is no firm formula. He argued that a broader view than mere

¹² UNFSA = UN Fish Stocks agreement

attachment to a specific zone and historical catches should be adopted. He believed there might well be a need to reshuffle and look at the pelagic complex in its entirety.

The overall conclusion from the Session was that, although there is no general internationally agreed upon allocation formula, the States Parties in the North East Atlantic Ocean region have had reasonable success in the management of the pelagic fish resources in the area. Breakdowns are mostly related to ecosystem changes when fish species change migration patterns and distribution areas. At the same time, new thoughts have emerged on how to improve the future management of these stocks.

Session 6. – Taking stock – the quagmire of allocation.

At the close of the conference, time was set aside for a brief discussion in this Session on the “findings” of the conference. The discussion was, however, more a summation of the previous sessions rather than the anticipated “what next” perspective.

The conference closed with a definite sense among the delegates that the conference had been extremely worthwhile and that it was an excellent forum for the delegates to explore together the many issues confronting the pelagic fisheries in the region.

Chairmanships conclusions and recommendations

The overall goal of the conference was to facilitate a scientifically-based and politically relevant discussion on the future of the North East Atlantic pelagic fisheries. In this context, the title of the conference contained three key words: Challenges, Opportunities and Future. In order to adequately and appropriately explore these issues, the intent of the conference was to attract a broad and well-qualified participation from scientists, academics, political and business leaders, who were capable of providing accurate summations of the current situation regarding the pelagic fisheries and to address the many questions that are necessary to clarify and forge a prospective, scientifically-based policy for the sustainable development of the pelagic fisheries.

We believe the conference was a success. The expectations regarding the conference's scientific depth and relevant political discussion were achieved. The scientific presentations provided a complete and thorough examination of the challenges and opportunities for pelagic fisheries development. The political relevance of the conference was extremely high and underscored by the ongoing conflict over mackerel quotas in the region, which reached a high point while the conference was actually being held.

At present, the theme of the conference remains politically contentious and this found expression in several of the presentations and in the ensuing discussions. This was apparent not only in the political manoeuvring regarding national policy positions on the right to the mackerel stocks and the allocation of the stocks, but perhaps more so in the request from the assembled participants to the States Parties involved to resolve the conflict democratically and in good faith and on a scientifically prudent and sustainable basis. This point was welcomed and endorsed by the government officials who were in attendance at the conference.

While this report was being prepared, the conflict over the mackerel quotas remained unresolved and in fact escalated, leaving the States Par-

ties even farther apart. The goal of the conference to create a platform for joint dialogue on the future of the pelagic fisheries is more relevant than ever and should serve as an excellent example for future activities designed to foster dialogue and renewed collaboration.

Session Conclusions

Session 1

Session 1 was set aside for the fishing industry. Presentations outlined the developments in the fishing industry and the current challenges to improving the viability of the pelagic sector economy.

It was shown that the introduction of rights-based fisheries (particularly ITQs) had radically improved the sector's economy. However, the current trade policy regime within the North Atlantic, whereby certain countries restrict the landing of fish in other countries, constitutes a real obstacle to economic development in the sector.

The establishment of a forum similar to, for example, the Pelagic Regional Advisory Council (Pelagic RAC) based in the Netherlands, was suggested for the North East Atlantic. At meetings of such a council, fishing organisations and other stakeholders could discuss management issues and other issues of common interest.

All the various speakers addressed the need for the government authorities to find a way out of the current allocation structure. Furthermore, there was consensus that an ecosystem approach regarding the management of pelagic stocks should be adopted.

Session 2

The session outlined the complexity of the pelagic ecosystems in the North East Atlantic Ocean. The respective scientists offered explanations about several key factors that determine the dynamics of the ecosystems. However, a comprehensive understanding of the ecosystems remains elusive, especially now that climate change also seems to significantly influence ecosystem dynamics. A holistic view must necessarily include both the physical environment and the biota present at all trophic levels.

It is generally accepted that there are three large pelagic stocks whose interaction is not sufficiently known or understood. At present, the knowledge about the stocks biological cycle, migration and distribution patterns, and the underlying physical and biotic factors determining population dynamics is too fragmented. Therefore, it is difficult to provide the necessary input to the authorities engaged in the sustainable management of the stocks. Current stock management practices are consequently based on a simplistic understanding of the pelagic stocks.

A prospective stock management should be ecosystem-based, which is also recommended by the fishing industry, FAO and many other international organisations. The consequence is that the pelagic complex should be considered as a single whole and that a holistic approach be adopted to facilitate management of the pelagic stocks. Government authorities are, however, reluctant to conclude discussions about the stocks before there is sufficient scientific evidence regarding the dynamics of the pelagic ecosystems that can be used confidently in a sustainable management context.

Major research work is now called for both to understand and document the dynamics of the ecosystems, including the interaction of the fish stocks within these ecosystems. Not only is this work necessary from a purely scientific standpoint, but also to provide management relevant knowledge regarding the ecosystems and the interplay of the fish stocks. The need for this research is now greater than ever and will only increase over time. Therefore, it is necessary to discuss how future research can better contribute to a more systematic and holistic management.

The Nordic marine research institutes are internationally recognised and are well-reputed for the quality of their scientific research. They are both professionally and administratively capable of leading the collaboration between all stakeholders and other relevant marine research institutes on the aforementioned research work. The various research councils from the Nordic countries and NordForsk no doubt will assist in the financing of this research work.

Session 3

The session outlined the technological challenges and opportunities for improvement in several areas. Technological advances can increase the value of each catch. Moreover, new technology exists to reduce expenses, especially oil consumption.

The carbon footprint of the pelagic fisheries is considered fairly minimal. This is a competitive advantage that the pelagic fisheries can exploit.

Much of the pelagic catch is processed into animal feed, especially for salmon. Some discussion has arisen whether this production is ethical, especially if the pelagic catch could be processed for human consumption instead. The conclusion reached by most delegates was that such production is ethical, as long as there is not a true market for the catch as food for human consumption. The delegates concluded that it would be wise to monitor this issue as there is an ever increasing need for food the world over and the pelagic fisheries could easily and quickly respond to this need. It was noted that the pelagic fisheries should remain focused on technological flexibility.

Session 4

Session 4 discussed the socio-economic conditions relevant to the management of pelagic fisheries. Analysis of the North East Atlantic pelagic fisheries social return found that the pelagic fisheries as a whole are operated in an economically optimal manner. The maximum social return (i.e., resource rent) could exceed 40% of landing value, provided a radical rights-based fisheries is implemented. Profit distribution among owners, fishers and communities differed among the Nordic countries.

Scientific analysis should give rise to national discussions about how a country's natural resources are maximised and how natural resources are allocated among vessel owners, the fishers themselves, and the community-at-large. Most fisheries laws in our region stress that the fish resources belong to the people or are the property of the country. Resource rent is considered a part of the return from fishing, generated for the country by the fishing vessels because they get access to the raw material essentially for free.

Maximising resource rent can be done nationally by rationalising the existing fleet, but maximisation can also be accomplished internationally by aligning the entire regional fleet to the resource base. A social dimen-

sion is always an underlying premise of any system of management, although a management system does not always directly address social objectives. Experience shows that much more attention should be given to the social dimensions in order to create the necessary social legitimacy for management systems, even though it is often stressed that fisheries policy should not be used for regional or social policy purposes.

The Nordic countries have different experiences regarding the blending of regional and social policy and labour market policy with a fisheries policy and there is ongoing research examining the relationship between these policies. Maximising resources leads inevitably to fewer and larger vessels in the fleet and thereby the concentration of capital. This development without a doubt will bring regional, social and labour market issues more and more into the debate on fisheries policy.

Session 5

Session 5 immersed itself in the issue of allocation, which is also the political problem in the ongoing debate on mackerel. The delegates learned that neither of the international conventions, UNCLOS or UNSFA, contain a suitable toolbox with the necessary instruments to easily facilitate the sharing of common stocks among coastal States. Although there are other areas of the world that have similar distribution challenges as here in the North East Atlantic, there was some concern about the applicability of that experience to the North East Atlantic.

The challenge of developing suitable mechanisms for allocation was greatly stressed. Proposals were made for various tools and models that could be explored in the ongoing development of allocation methods and instruments, some of which no doubt a country could review further and implement to advantage.

In connection with the discussion of an international pelagic fleet, it was suggested to develop a "quota bank" to which countries would assign their allocations. Via an auction system, individual vessels within the international fleet could freely and in competition against each other bid for quotas. Revenues from the auction are a reflection of an appropriate resource rent and thus the property of the countries participating in the scheme.

Further research into these issues is being carried out and looks promising. Moreover, marine research in the Nordic region is also in the fore-

front and will be able to support discussion on the best sustainable practices in fisheries management. This research should therefore remain a priority in order to assist in the progressive development of the pelagic fisheries. Ongoing discussion of these important issues needs to occur not only within the industry itself, but also among the various governmental institutions and authorities. Furthermore, the issue should certainly be discussed in public forums, as no doubt the general public is keenly interested in this issue as well.

Recommendations

1.

Generally, it is recommended that discussions on the pelagic complex in the North East Atlantic Ocean should continue on the national level, as well as in regional forums and internationally, where similar conditions as in the North East Atlantic might exist. The conference delegates were exposed to a wide range of challenges and opportunities within the pelagic fisheries that require further and more in-depth exploration as management of the pelagic fisheries continues to develop.

2.

It is recommended that a North East Atlantic pelagic fishing organisation be established, whose members would be comprised of various fishing organisations and other relevant stakeholders. In order to improve the negotiation climate, it is considered absolutely fundamental that the various fishing organisations in the area have a forum where they can discuss issues and possibly agree on recommendations to carry forward to the political authorities.

The relevant fisheries organisations could take the initiative to open up a discussion about whether a specific proposal could be considered sustainable. Moreover, such an organisation could have direct linkages to NEAFC.

3.

It is recommended that major, management-related scientific research be carried out on an ecosystem-wide basis. The research initiative should focus on a holistic approach to the pelagic complex. Second, the research should explore the dynamics of ecosystems, as well as generate knowledge relevant to the overall management of the pelagic stocks in the region.

The directors of the various marine research institutes in the region could appoint a small committee for the purpose of identifying specific problem research areas and organising the necessary research efforts that would provide the relevant knowledge.

The various research programmes could be presented for funding to not only NordForsk and the various research councils from the Nordic countries, but also the European Union.

4.

It is recommended that the internationalisation of the pelagic fleet continue to be discussed and studied and that these efforts be accelerated. Initially, research on this issue should be intensified to generate a solid knowledge-base for discussions. In parallel, discussions should take place within the various fishing organisations (possibly in the proposed pelagic fisheries organisation recommended in point 2 above).

Conditional on the success of research and stakeholder interest, the governmental authorities could continue working on and discussing the formal foundation for internationalisation of the pelagic fleet. Also such initiatives as a quota bank, auctions, etc. could be linked with NEAFC to a certain extent.

5.

It is recommended to stimulate the development of allocation instruments or models. Initially, research projects and / or development projects could be initiated that might also include research on the collapse of negotiations and subsequent agreement on herring (2003 – 2006) and blue whiting (2003 – 2005). It is also important to look at the international experience in the field.

Via NEAFC, the countries involved could construct a proposal for a research and development package focused on allocation instruments or models.

Appendices

Opening address

By Jacob Vestergaard, Faroese Minister of Fisheries

Distinguished guests, ladies and gentlemen, On behalf of the Faroese Ministry of Fisheries and the Nordic Council of Ministers, I would like to welcome you to the Faroe Islands, to the Nordic House, and to the Conference on the Pelagic Complex.

Attending The Pelagic Complex Conference will be representatives from the fisheries industry, politicians and scientists from all the countries that have a stake in pelagic fisheries in the Northeast Atlantic.

Due to the rotation in Nordic cooperation, Denmark has the presidency in 2010. The Faroe Islands holds the Presidency of the Nordic Fisheries Cooperation. When developing the program for 2010, Faroe Islands emphasised the need to have a broad discussion on the pelagic stocks in the North East Atlantic.

Planning for the conference began more than a year ago. The Nordic Council of Ministers considers one of its most important tasks is to ensure that fisheries issues are aired properly and openly in the Nordic cooperation. The Council of Ministers has repeatedly stressed how vital fish resources are for all of the Nordic countries. The pelagic species have migration routes which pass through the national waters of several Nordic countries, and it is crucial that these nations have a common platform from which they can discuss the relevant issues and challenges.

The pelagic fishery in the North East Atlantic represents a fishery with a catch value of 1.3 billion Euros per year. All countries in the region exploit these common resources and the fishery is therefore of great importance to the coastal communities in the region – not least for the Faroe Islands.

The programme of the conference gives us great opportunities for a deeper understanding of many aspects of the exploitation of pelagic stocks

and how we manage the stocks jointly. It will always be a challenge to explore the opportunities to increase the value of the catch, either on board or in the industry on land. Today, the catch value of the different species lies between 0.1 and 1 Euro per kg. The conference will hopefully show us some ways to get more value out of the stocks and how we can reduce the cost of the fishery by looking at relevant technological developments.

To understand the pelagic stocks migration and distribution patterns is a great scientific challenge. Hopefully the experts can give us an answer to what is happening in the ecosystems in the North East Atlantic and can give us better insight into the dynamics of the stocks.

As mentioned earlier the pelagic fishery is of great importance to the coastal communities in our region. An analysis which will be presented at the conference concludes that in economic terms the management of the pelagic fisheries is excellent. In total the fleet operating in the region is able to generate a significant resource rent. Therefore the North East Atlantic management could be model for pelagic management worldwide.

It will be interesting to hear how economics look at even higher resource rent and how the rent could be distributed in the future.

It is my hope that this conference can contribute to a comprehensive debate, about how people, whose livelihoods depend on harvesting from the sea, can best exploit these resources efficiently and sustainably, also in the future.

The conference is an excellent opportunity to hear a broad presentation of viewpoints in the pelagic sector. It is through a conference of this kind, where everyone has their say, that we can lay a sound foundation for discussions in the future at a political level.

I wish you all luck with the conference on the Pelagic Complex which I hereby declare open.

Abstracts of presentations

Session 1

Extract of input from Bergur Poulsen at the Pelagic Complex conference 7–9 sep. 2010 in Tórshavn.

Bergur Poulsen, director P/F Havsbrún

Fishing, stocks, politics, fishmeal and fish oil

- The on shore value chain for pelagic fish in the Faroes at present goes from whole fish to whole frozen, filleting, fishmeal and oil, fish feed, salmon production and portions etc. The players involved on shore are Faroe Pelagic (whole frozen and filleting), and Havsbrún (fishmeal and oil, fish feed, salmon production). A look at the stocks involved in the Faroese pelagic fishing at the moment, with an estimate on the migrating routes.
- A comparison between the TAC (approx. 3,2 mill. ton) in the Northeast Atlantic and what only one species of whale, the minke whale, eats out of the stocks (approx. 2 mill. ton).
- A comparison between the value of the pelagic fishes the Faroe Islands do with Russia each year in exchange for demersal fish, and the estimated financial outcome in 2010. Result for 2010 – minus 159 mill. dkk which corresponds to over 20 mill. €.
- The figures on how much pelagic fish from the Faroese quotas was landed on the Faroes in 2009, and how much was landed abroad. Landed on the Faroes approx. 29% round weight and approx. 26% of the first hand value.
- An examination on how our neighbours in the North Atlantic show that they have systems in place which directs as much pelagic fish as possible to be landed in the respected countries, whereas the Faroese boats have no bindings what so ever. Also an overview on how other systems like vertical integration and landing agreements are integrated in our neighbouring countries.

Fish feed and fish farming

- The companies – 5, sites -26 and how much fish – 70.000 MT can be farmed on the Faroes today. As well as how the sites are distributed around the islands.
- A historical overview on the Havsbrún fish feed sales back to 1981 when the fish feed factory was established, divided on domestic sales and export. Now approx. 60.000 MT.
- A small slide on marked expectations when it comes to farmed salmon. (Kontali)
- Looking at how the aqua culture has grown worldwide over the last 25 years from 20 mill. MT to almost 50 mill. MT, and how both fishmeal/oil and the inclusion rates of fishmeal/oil have decreased from 50%/35% to 15%/10%, and how this corresponds to pelagic fish from the ocean to support the salmon production. A few figures on the ratio between fish from the ocean and the salmon production, in 2010 1,8 kg. of fresh fish for 1 kg. of salmon and in a few years time 1 kg for 1 kg. Also a comparison between the value and the profitability in fish being used directly for human consumption or used for meal/oil – fish feed – salmon – filets – human consumption, where it at the moment is about 10 fold more profitable for the whole chain to do the conversion to salmon, and the value pr. kg. fish is about 4 fold.

Challenges and conclusion

- The challenges the Faroese industry faces in the pelagic sector, to mention a few – quotas, seasonal catching, unpredictability, labour, high investment costs and huge stores. But where the biggest challenge of them all is international – to agree on the how to manage the stocks.
- A conclusion which states that we need long term clear Faroes policies which ensures the highest yield for the whole Faroese community, and not only a few fragments of the industry. How the free competition on pelagic raw material only applies to the Faroe Islands, and how we today have a huge loss on the exchange with Russia, as well as doubting the reason to sell about three quarters of the rest of the pelagic raw material to our competitors abroad without any hesitation.
- A conclusion which states that we most likely will need both the consume marked as well as the fishmeal/oil – fish feed – salmon

production – filleting marked in the future as there will be an increasing demand for marine proteins in the future.

Challenges for the catching sector – seen from a Danish point of view

Christian Olesen, director Danish Pelagic Producers Organization

- Overview of the Danish Pelagic fishing fleet What has happened since introduction of ITQ
- The organization in Denmark – PO's, DFF
- The Pelagic Complex – stock by stock – challenges: biology, allocation, HCRs
- How does DPPPO handle the challenges?
- RACs – Pelagic in particular – composition, structure. Example from case in PRAC
- How do we evolve the stakeholders' influence on policy decisions in the future?

Development of the Pelagic industry in Iceland

Gunnþór Ingvason, director Sildarvinnslan

Dramatic changes have occurred in the pelagic industry in Iceland over the past few years. It has gone from a fleet of small fishing boats and producers in every small town with hundreds of workers to big vessels and enormous plants and much fewer land-based workers than before.

In the seventies we had hundreds of boats and thousands of fishermen. Today one vessel is taking about two thousand tons, which required 5 to 6 boats in the eighties. There were 170 boats fishing 35,000 tons of herring 1979 with about 2000 fishermen; in 2009 there were 14 boats fishing 47,000 tons of herring with about 170 fishermen. Today we have bigger vessels with tanks and RSW cooling systems that give us much better raw material.

We have seen the same development in the fish meal factories; today we have bigger factories with more automation. In the last 6 -years the factories have gone from 19 down to 11 with total capacity of 11,250 tons per day.

We have 9 pelagic freezing factories with capacity of about 2,800 tonn per day, and 7 factory vessels with capacity of about 11,000 tons per day. One factory can take up to 800 tons of herring to filleting per day with 24 employees per shift. This tells us that we need 50 people today to take the same quantity per day as we needed between 400 to 500 fifteen years ago.

Next we look into the value chain between fishing and processing. We control the resources by quotas and the fisheries are controlled by the processing options. The processing options are controlled by the market for fishmeal, fish oil and for various products for human consumption.

We have possibilities to optimize the value of the catch. We take the fish into human consumption and can grade the smaller fish to meal and oil, we take all the trimming from the processing for human consumption and redirect them to meal and oil. When the fat is high in the fish and the meal and oil prices are high it can be more valuable to take the fish into meal and oil.

In the last years we have seen drastic changes in the quantity of pelagic catch. For the past fifteen years we were used to fish over one million tons. In more recent years the quantity has fallen down to five hundreds thousands tons and at the same time more and more of the fish goes to human consumption.

This change has led to merging of pelagic companies so to day we have fewer and stronger companies. This has led us to merge quotas on fewer vessels. The Icelandic quota system has given us the oppurtunity to grow and become economically efficient despite reductions in TACs.

The companies have utilization rights of the resource through the quota system. Maximizing the value of catch and sustaining the fishing stocks is the win/win situation for the companies.

The companies have the whole value chain implemented and that has led to drastic changes in the industry. This has given us the opportunity to build up strong companies in the pelagic sector in Iceland. Companies that are able to cope with the drastic changes that always occur in the fish stocks and different market situations.

The Pelagic Complex in the Northwest Atlantic Ocean: Challenges – Possibilities – Future

Audun Maråk, director, Norwegian Shipowners Association

Sustainable management no. 1 of challenges

- Knowledge on biology
- International agreements a major part of sustainable fisheries management

Eco system management

- Consider fish stocks and the ocean together
- Industry in North Atlantic must press for increased finance for science
- Even stronger cooperation within or between marine science institutes
- Increased knowledge through eco system management

Coastal state agreement – mackerel

- Allocation must be based on mackerels zonal attachment
- Mackerel's zonal attachment in various zones in time and volume. Must be seen in a 15-20 year perspective
- Seen in a 20 year perspective hardly any argument for Iceland's coastal state claim, nor allocation claim
- Experience shows we cannot circumvent historical catches in allocation discussions, Iceland's position weak also here

Prospects for the future bright

- Pelagic fish still low value, potential for higher prices
- Healthy food
- Big potential in by-products, f.ex Health- and body related products
- Environmental performance – Pelagic fisheries top performers
- Agreement on management. Mackerel the challenge
- Allocation based on stock's zonal attachment over time must be rooted, and common, basic rules established. Nowadays, no basic principles.
- Scientists are allies of industry. Scientific community must be strengthened.
- Lasting long term agreements and multi-species/wider eco-system management the key to the treasure chest

Session 2

Changes in distribution of Norwegian spring-spawning herring, blue whiting and northeast Atlantic mackerel in the Norwegian Sea in recent years.

Asta Gudmundsdottir. Senior scientist, Marine Research Institute, Iceland.

It is known that environmental changes can affect distribution of fish stocks. Since the mid 1990s warming has been observed in the North Atlantic. Changes in distribution have been observed for some pelagic stocks in the NE Atlantic at the same time. The Norwegian spring-spawning herring stock, the blue whiting stock and the northeast Atlantic mackerel stock are widely migrating stocks, which all utilize the Norwegian Sea and adjacent waters as their feeding area in spring and summer. Changes in distribution during their feeding seasons have been observed in the recent years. The Norwegian spring-spawning herring stock resumed the feeding migrations into the Norwegian Sea during the mid 1990s that ceased when the stock collapsed. The border of the feeding area for herring is considered to follow the Arctic front. During the 1990s the Arctic front was generally found further east than before and in the 2000s the Arctic front moved further west. Simultaneously the stock was found to feed progressively further south and west. From the mid 1990s to mid 2000s a series of very strong year classes in the blue whiting stock appeared. With the increasing stock the distribution of blue whiting expanded. Since 2006 the recruitment of blue whiting has been poor and the stock has been declining since then. The distribution area has shrunk and is mainly east in the Norwegian Sea. In recent years mackerel has been observed both more northerly and westerly than before. In a newly finished International Ecosystem survey in the Nordic water mackerel was found up to 76°30 and all around Iceland.

Primary Production around Iceland and Faroes

Li Zhai¹, Kristinn Gudmundsson², Peter Miller³, Wenjun Peng¹, Hafsteinn Guðfinnsson², Héðinn Valdimarsson², Sólveig Ólafsdóttir², Høgni Debes⁴, Hjálmar Hátún⁴, Ellie Doggett¹, Marie-Hélène Forget¹, George White¹, Shubha Sathyendranath³, Trevor Platt³

¹Bedford Institute of Oceanography, Canada, ²Marine Research Institute, Iceland, ³Plymouth Marine Laboratory, UK, ⁴Faroe Marine Research Institute

We discuss the estimation of primary production in the Iceland-Faroes region through synthesis of all available data, both *in situ* and remotely-sensed. Most of the *in situ* results used were collected over many years by the Icelandic scientist Thorunn Thordardottir (1925 – 2007): she has left us with a magnificent legacy of information concerning the phytoplankton of the Icelandic Seas. Moreover, she had the great foresight to measure, at sea, the parameters of the photosynthetic response of local phytoplankton to available light on many stations, over a period of many years. It is a demanding measurement. Without her investment, we would not have been able to carry out the work reported here.

Oceanographically, the study area is complex, and may be partitioned according to hydro graphic understanding, into four regions (Figure 1). A detailed frontal analysis shows that this partition is a dynamic one. Using remotely-sensed data on ocean colour, we have established climatological time series of chlorophyll for each of the four regions (Figure 2).

Previous estimates of annual primary production were made solely on the basis of simulated *in situ* experiment conducted at sea. Although the network of stations occupied is unusually rich (Figure 3a), and the data accumulated over many years, the resultant map of estimated annual primary production is strongly influenced by the results at individual stations. The advantages of combining the ship data with remotely-sensed data on visible spectral radiometry (ocean colour), for which the principal deliverable is concentration of chlorophyll, include superior spatial resolution and better temporal coverage.

Figure 1: Bathymetry and circulation around Iceland. Based on knowledge of the local water masses, the study area is divided into four regions by blue lines. The yellow circles (one for each region) show the areas averaged for representation of region-specific properties.

Figure 2: Climatology of chlorophyll concentration at four selected locations indicated by yellow circles in Figure 1.

To estimate primary production from remote sensing, we need to assign, for every pixel in the remotely-sensed chlorophyll field, the parameters of the photosynthesis response and the parameters for the vertical distribution of chlorophyll. Here, the archived data on these parameters acquire central importance. We have compared both sets of parameters for Iceland with other sets determined independently in the NW Atlantic, and found good consistency between them. We use a method for parameter assignment that searches the archives for observations made near the values of surface temperature and chlorophyll (as determined by remote sensing) for the location and date of the pixel concerned (Nearest Neighbour Method). Using this method of parameter assignment, we have calculated the primary production for the domain of interest through the period of availability of remotely-sensed data on ocean colour. The climatology of annual primary production determined in this way is shown in Figure 3b. It agrees well with observations made by the simulated in situ method using ships as a platform, but, inevitably, the fields produced from the remotely-sensed data are smoother. In general, these estimates favour a rather smaller value for annual primary production than estimates from ship data.

Figure 3: (a) Annual primary production estimated made solely on the basis of in situ data, and (b) Primary production through water column, calculated using Nearest Neighbour Method, for period from March to October.

Figure 4: Thorunn Thordardottir (1925 – 2007).

This work is dedicated to the memory of Thorunn Thordardottir, pioneer of phytoplankton dynamics around Iceland, compiler of a massive data base on this subject, and a much-valued colleague (Figure 4).

Variation in hydrography, plankton productivity and fish distribution in the Northeast Atlantic

Hjálmar Hátún. Senior scientist, Faroe Marine Research Institute.

The recent northwestward expansion of the northeastern Atlantic mackerel stock represents a challenge for reaching an inter-national fishery agreement that is satisfactory for all involved nations. Speculations on a potential link between the mackerel ‘out-burst’ and Global Warming are often posed, although based on a weak foundation. We have previously demonstrated that the large decline of the North Atlantic subpolar gyre after the mid-1990s resulted in much elevated temperatures and salinities in the northeastern Atlantic, shifts in ecologically important plankton communities, an expanded spawning distribution, a more westerly post-spawning migration and a large increase in the spawning stock of the pelagic gadoid blue whiting (*Micromesistius poutassou*). Building on these results, we here speculate on a potential interplay between blue whiting

and the mackerel stocks and the marine climate. These fish stock occupy similar niches in the ecosystem, and their positions in the dominance hierarchy alternates. We show that the spatial expansion of mackerel is not simply a response to increasing temperatures. We hypothesize that the causality lies in the drastically declining blue whiting stock, which in turn is caused by both the marine climate and by a very large fishing pressure.

Plankton production in the Nordic Seas

Webjørn Melle. Scientist, Institute of Marine Research, Norway.

Annual average biomasses of pelagic populations at various trophic levels in the Nordic Seas are not very different. However, annual production and even more, consumption, declines sharply towards higher trophic levels. Due to short life cycles, distribution and abundance of planktonic organisms are inherently difficult to map. Therefore, estimates of geographical distribution within a year and interannual differences in abundance between years must be used with care. Krill (mostly *Meganyctihanes norvegica* and *Thysanoessa inermis*) during the years 1990-2004 were widely distributed within the Nordic and Barents Seas (Fig. 1). Possibly, minimum concentrations were found in the central, deep Norwegian Sea. Total biomass was estimated at 160 mill. tonnes. Amphipods of the genus *Themisto*, showed a clearly Arctic distribution. Total biomass was estimated at 50 mill. tonnes (Fig. 2).

Horizontal distribution of mesozooplankton as measured during the ICES coordinated surveys of the Nordic Seas with vertical net hauls with WP2 nets from 200 m depth to the surface, has changed dramatically during the 15 years time series. The typically elevated plankton biomass in the western Arctic waters observed during the 1990s is no longer there. Further, a general reduction in biomass in all areas is evident (Fig. 3). Timeseries of average biomass within a western and eastern region confirms the general reduction in biomass since the start of the sampling program (Fig. 4). The changes in average biomass within water masses show how biomass of Arctic water have gone through the strongest reduction (Fig. 5), and differences in the timeseries within water masses explain the changes observed in horizontal distribution. It is probable that the present very low plankton biomass, which is representing the main food

of pelagic fish stocks of the Nordic Seas, will affect feeding migration and growth of the fish (Fig. 6).

In the presentation aspects of the population dynamic of the major herbivore *Calanus finmarchicus* are related to the environment and it is shown how it may govern herring feeding migration.

Can the Norwegian Sea accommodate three large pelagic stocks at the same time?

Jens Chr. Holst. Scientist, Institute of Marine Research, Norway.

During the years 1995-2004 extreme recruitment was observed in the stocks of Norwegian spring spawning herring, blue whiting and mackerel feeding in the Norwegian Sea and adjacent areas, leading to total stocks of pelagic fish probably exceeding 25 million tonnes. Parallel with the following strong increase in grazing pressure, a strong decrease was observed in the plankton resources constituting the main food items for the fish stocks. This mismatch between grazing pressure and food has led to poor individual growth in the fish stocks and probably also reduced recruitment. In addition there are strong indications of lack of food in stocks of marine mammals and sea birds, judging from reduced reproductive success and feeding migrations out of the area. Periods of high and low productivity in the Norwegian Sea can be traced back in time through the ratio of one sea winter salmon on multi sea winter salmon in European rivers, where a low ratio indicate periods of reduced productivity, low growth and starvation. It is hypothesized that the Norwegian Sea ecosystem is cyclic and linked with the Atlantic Multidecadal Oscillation (AMO), that we are now entering a downturn of the AMO where strongly reduced pelagic fish stocks could be expected and that grazing will have to level productivity before the system is reset and renewed growth can be observed. These findings, if correct, will have large consequences to our conception of the management of the pelagic ecosystem of the NE Atlantic and a future management regime aiming at balancing grazing and productivity, rather than fishing the pelagic stocks at fixed proportions is suggested.

How will climate change affect the Northeast Atlantic and the Nordic Seas

Bogi Hansen. Head of Section on Environment, Faroe Marine Research Institute.

During the decades and centuries to come, climate change will affect the terrestrial and marine environment in many different ways. The main tools, available to us for predicting these changes, are the climate models, running on large and fast computers. These models are generally considered fairly reliable as predictors of some global mean properties, such as the global mean surface temperature, as long as realistic scenarios for greenhouse gas emissions can be prescribed.

To some extent, the models may also be able to forecast some large-scale regional variations. Thus, the surface ocean is generally expected to warm less than continental areas. The North Atlantic, in particular, will, according to many climate models, experience less warming than most other regions, except for the high-latitude areas that today are ice covered, at least seasonally.

In this first approximation, the Northeast Atlantic and the ice-free southeastern parts of the Nordic Seas will therefore be among the least affected regions on the globe. There are, however, some caveats to this; first of all, the uncertainty about emission scenario. If the most pessimistic scenarios are combined with a higher than expected climate sensitivity, the Northeast Atlantic and Nordic Seas may still expect large warming.

The fairly optimistic picture, painted above, is also dependent on other assumptions; primarily the assumption of a continued strong and stable North Atlantic Thermohaline Circulation (THC). The THC is an integral part of the link between the Northeast Atlantic and the Nordic Seas. In the Nordic Seas, cooling by the atmosphere makes surface-near waters become denser and sink, after which they cross the Greenland-Scotland Ridge (GSR) into the North Atlantic as cold and dense overflow water (Fig. 5). The overflow water is diluted and augmented by entrainment in the Ridge area and it provides the main part of the deep branch of the THC.

Figure 5: Warm Atlantic waters flow across the Greenland-Scotland Ridge into the Nordic Seas (red arrows) where they are cooled. Most of this water sinks and flows back into the Northeast Atlantic as cold and dense deep overflow (white arrows).

By the removal of overflow water from north of the GSR, the high-latitude cooling at the same time generates a sea level slope that drives a large part of the inflow of warm saline water towards and across the GSR. This flow has a strong influence on the conditions southwest of the GSR and is essential to the conditions northeast of it.

According to the IPCC 2007 Assessment Report, it is very likely that the THC will weaken in the 21st century, but the magnitude of the weakening is uncertain. Most important for our region is, however, the question, how much of the weakening will occur in the Nordic Seas source. Current climate models indicate that most of the weakening, perhaps, may occur in the Labrador Sea contribution to the THC, but the ability of most models to reproduce observed features of the THC is fairly limited and their ability to forecast future THC variations, therefore, somewhat uncertain.

Thermohaline ventilation in the Labrador Sea also has a strong influence on the extent and strength of the Subpolar Gyre, which has been shown to affect both physical and biological conditions in the Northeast Atlantic as well as the Nordic Seas.

The physical conditions in the Northeast Atlantic and Nordic Seas under climate change are, therefore, not easy to predict with any certainty.

When extending this to marine ecosystems, we have to add the uncertainties in some atmospheric parameters, notably the wind. Wind conditions influence the location of fronts and the depth of the mixed layer, essential for primary production. According to the IPCC 2007 Report, storm tracks are likely to be shifted by climate change but, again, the details of these changes are difficult to forecast with current climate models.

Summarizing, physical as well as ecological conditions in the Northeast Atlantic and Nordic Seas are likely to change in the 21st century, but the magnitudes of changes and, in some cases even the direction, is hard to predict at this stage.

Climate change and fish distribution

Grégory Beaugrand. Senior scientist, University of Lille, France.

Climate change is unambiguous and its effects are clearly detected in all functional units of the Earth System. This talk presented new analyses of sea surface temperature changes and showed that climate change is affecting the spatial distribution of both plankton and fish in the North Atlantic. Changes are seen from phytoplankton to zooplankton to fish and are modifying the dominance of species and the structure, the diversity and the functioning of marine ecosystems. Climate changes have implicated strong biogeographical shifts in the North-East Atlantic. These alterations reflect a response of pelagic ecosystems to a warmer temperature regime. Mechanisms are complex because they are nonlinear exhibiting tipping points and varying in space and time. Sensitivity of organisms to temperature changes is high, implicating that a small temperature modification can have sustained ecosystem effects.

Biogeographical shifts have been observed in the Northeast Atlantic. Major biogeographical shifts took place since the early 1980s to the southwest of the British Isles and from the mid 1980s in the North Sea. Among plankton (calanoid copepods), the number of warm-temperate and temperate pseudo-oceanic species increased northwards while the number of cold-mixed water and subarctic species assemblages decreased. All assemblages showed consistent long-term changes that appear to reflect the response of the marine ecosystems towards a warmer dynamic regime. Studies have subsequently revealed that the biodiversity of calanoid co-

pepods are responding quickly to sea surface temperature rise by moving geographically northward at a rapid rate up to about 23.16 km.yr^{-1} . This rate is far superior to what is commonly reported for the terrestrial realm. Examination of fossil pollen suggests that migration of trees during the post glacial warming in North America and Europe was between 100 and 1000 m.yr^{-1} although recent results suggest such rates could have even been even overestimated (Pearson, 2006). Thomas & Lennon (1999), investigating 59 breeding bird species over the United Kingdom, detected a northward shift of 18.9 km in 20 years, an average shift of 945 m.yr^{-1} . A meta-analysis conducted on 1700 species or taxonomic groups at a global scale reported a poleward shift of 610 m.yr^{-1} (Parmesan & Yohe, 2003). Parmesan et al. (1999) detected a maximum range shift for butterfly of 200 km over a period of 40 years, therefore a maximal movement of 5 km.yr^{-1} . Although some sea surface temperature isotherms have moved northwards by an average rate of up to 21.75 km.yr^{-1} (e.g. the North Sea), their movement cannot fully quantify all species assemblage shifts. Other processes such as those described in the talk of Hjálmar Hátún may have contributed. Fish has also responded to temperature change in the North-East Atlantic. This has been shown for subtropical fish by Quero and colleagues (1998), for commercial species by Brander (2003) and more recently by Perry and colleagues (2005).

Recent strategies to sustain fish stocks have suggested a move towards an Ecosystem Based Fisheries Management (EBFM) approach. While EBFM considers the effect of fishing at the ecosystem level, it generally ignores climate-driven environmental variability. This talk showed that the position of a fish stock (e.g. Atlantic cod) within its distributional range or ecological niche will influence the relative importance of fishing and climate on abundance. At the centre of its niche, stocks are less influenced by climate-driven ecosystem changes while at the edge this influence can be prominent. Thus, while it is essential to control fishing effort to mitigate the declines observed in many fish stocks, climate and its effects on the ecosystems that sustain fish production should also be considered in the management of marine resources. Recognising the potentially strong effect of climate, at a time of rapid global climate change, is probably an important prerequisite in the elaboration of cod management plan.

Projections of change in fish distribution suggest major modifications in the spatial distribution of fish that could exceed 10° of latitude by the

end of the century. Scenarios of changes vary according to species, the intensity of warming and the ocean-atmosphere general circulation model used. However, they indicate potential major reorganisation of biological systems for the end of this century.

The conclusions of the talk were:

- Recent studies therefore revealed that climate change may strongly alter fish stocks.
- Climate controls the spatial distribution of fish. Each species has a unique spatial distribution, which is determined by its bioclimatic envelop.
- Inside the spatial distribution of a species, overfishing has strongly reduced fish stocks.
- Climate change will modify the spatial distribution of species, the impact of climate will depend on the intensity of warming.
- The impact of climate will be prominent at the edge of the spatial distribution (and bioclimatic envelop) of the species. At the southern edge, warming will negatively impact stocks and at the northern edge, it will positively impact the stock.
- In all cases, we need to control fishing. At the southern edge of the spatial distribution of the species (warm edge), overfishing may precipitate climate-induced collapse of fish stock. At the northern edge, it may jeopardize the increase in fish stock triggered by climate.
- Our projections are highly dependent on the intensity of warming.
- It is perhaps easier to forecast the collapse of a species than anticipating the arrival of new species.

Challenges to the Russian pelagic fisheries

Alexander Krysov. Head of Pelagic Section at PINRO, Russia.

In the paper is given review of the Russian pelagic fishery in the North-eastern Atlantic.

Russian pelagic fishery in the Northeastern Atlantic is based on five fish target species. The Atlanto-Scandian (Norwegian spring-spawning) herring, blue whiting and the northeastern mackerel are harvested by Russian fishing vessels in the Norwegian Sea and adjacent waters. Capelin

and polar cod are fished in the Barents Sea. In 2009, the Russian catch of pelagic fish in the Northeast Atlantic equaled to almost 500 thousand t.

Only the Barents Sea polar cod is a national stock. Russia is a coastal state in relation to the stocks of herring and capelin and it has a status of an invited observer at the international meetings on the management of blue whiting stock and gets the part of mackerel catch in the international waters of the Norwegian Sea as a traditional user and organizer of the mackerel fishery in this sea area.

Recently, the trend of the reduction in the pelagic fishery in the Norwegian Sea has appeared. The blue whiting stock has been drastically decreasing due to the absence of strong year-classes after 2002 and significant overfishing in the middle of the last decade. Herring population shows greater reduction than it was expected owing to a number of poor year-classes after 2004. Only the population of mackerel demonstrates stability which might be affected by overfishing. And on the contrary, the stocks of capelin recovered in 2008 and polar cod of the Barents Sea are in a relatively good condition. As a result of that, the pelagic fishery in the Barents Sea is increasing as opposite to the Norwegian Sea though the fishing objects are not equal in the respect of their valuability.

Russia, as a member of "clubs" of the coastal states, has always been following the international agreements in the relation of management of water biological resources. These are the international agreements which are a basis for rational exploitation of the joint fish stocks.

Session 3

Pelagic fisheries – vessel and gear design

John Willy Valdemarsen. Institute of Marine Research, Norway.

Fishing vessels fishing for pelagic resources in the Northeast Atlantic Ocean range in size from small 10-15 m vessels catching mackerel with automatic trolling machines till large pelagic trawlers, 145 m in length having engines of 22 000 Hp. The majority of pelagic fishing vessels are equipped for purse seining, trawling or both fishing methods. In Norway purse seining is still the preferred fishing method for pelagic species like herring, sprat, mackerel and capelin (85% of total catch since year 2000), whereas Iceland the Faroe Island recently have converted to more pelagic trawling for the same species (Iceland about 50:50 share of the catch the last 5 years). Other European nations mainly exploit pelagic fish in the NE Atlantic with pelagic trawls. Blue whiting is only fished with pelagic trawls.

Pelagic fish are often shoaling and therefore localization of such fish aggregation is an important part for pelagic fishing operations. Sonar is the best equipment to locate catchable shoals and modern sonar can estimate quantity and shoal movement prior to shooting a purse seine. When the shoal is encircled the fish is pursed and accumulates in the bunt of the net. The fish is pumped onboard the vessel into RSW tanks where they are kept till landing.

Fish that are captured with trawls are similarly pumped from the codend onboard the vessel and in most cases stored in RSW tanks. Some vessels are equipped for block freezing of the catch and a small number also have processing onboard.

The purse seines are mainly produced of PA netting and range in size from 500 till 1000 m length and depth from 150 till 250 m.

The trawls used in pelagic fisheries all have large mesh front parts, and codend mesh sizes tailor-made for the target species (20 – 50 mm). The large mesh trawls developed in the first half of the 70-ties was a breakthrough for pelagic trawling targeting pelagic species. Most pelagic trawls are now designed with front parts of parallel ropes, large diamond meshes (maximum 128 m, commonly 48 m) or large hexagonal meshes. The entrance of a pelagic trawl with a stretched circumference of 2000 m has a

vertical opening of 100 m and a horizontal width of 200 m when towed with a speed of 3,5-4 kn. Pelagic trawl doors are hydrodynamic efficient, mostly with a multi-foil design and with a large height/length aspect ratio (between 2 and 3). The door drag is 10-15% of the total gear drag. Therefore, reduction of the resistance of the trawl net can contribute more to the total drag reduction than modification of door design.

The trawl sonar is an important instrument in pelagic trawling to monitor trawl performance and fish entrance. Other helpful instruments for pelagic trawling are a winch control system, catch indicators and distance sensors. For pair trawling an instrument which detects and adjust the symmetry of the trawl when towing has proven to be very useful.

Pair trawling is often a more efficient technique to catch pelagic species than single boat trawling. Two vessels can tow a larger net and often faster than one vessel can alone. Another advantage is that two vessels can share one gear and thus reduce gear costs. When 3 or 4 vessels operate as a group non-fishing vessels are busy with transport and landing when two vessels are trawling.

In Norway a fully automatic trolling technique for mackerel has been developed and is used by smaller vessels.

A major challenges for the purse seine fleet is to catch the correct species and sizes so they can maximize value of their allotted quota without harming non-targets not taken onboard.

The main challenges for the pelagic trawlers relate to high fuel consumption, selecting the right targets and quality of the catch.

Range of pelagic fishing vessels (automatic trolling for mackerel and a purse seiner/trawler).

The most common pelagic fishing gears (pelagic trawl and purse seine).

Carbon footprint of Norwegian Pelagic seafood

Erik Skontorp Hognes, SINTEF, Norway.

The presentation showed results and findings from the report Carbon footprint and energy use of Norwegian seafood products¹³ by SINTEF Fisheries and Aquaculture (Norway) and SIK (Sweden).

The report quantified the climate impact from 22 different Norwegian seafood products, both wild caught- and aquaculture products. The carbon footprints were calculated by the Life Cycle Assessment (LCA) method. The following figure shows the system boundaries for the calculations.

¹³ You find full report here: www.sintef.no/Miljo/Miljoregnskap-for-sjomatprodukter

The main climate aspects of wild caught seafood are;

- diesel combustion and refrigerants emissions in the fishery
- processing, processing should be done before export to utilize the use of byproducts and transport capacity
- product form, products should be exported as frozen rather than fresh to allow for new transport means

Carbon footprint is high on the agenda for important stakeholders in the seafood value chain. Governmental bodies use carbon footprint to evaluate and choose strategies with less climate impacts. Big retailers wish to show their consumers that they are on top of things and demand that their suppliers can document their carbon footprint.

SINTEF Fisheries and aquaculture is the leading European technological research institute for the fishing and aquaculture sector. SINTEF Fisheries and aquaculture cover the entire marine value chain and work with the goal of contributing to sustainable use of marine resources at a national and international level.

Onboard handling systems, receiving and grading of pelagic fish

Leif Roger Gjølseth. MMC TENDOS AS, Norway.

MMC specializes in making complete packages consisting of fish handling and refrigeration equipment. The company is a leading supplier within its field of business. The annual turnover is more than 200 mill NOK, and number of employees are 85. With main office in Ålesund area, the company has branch offices along the coast of Norway from Stavanger in the south to Tromsø in the north. Furthermore, offices in Chile and Peru.

MMC is launching a brand new concept for loading, chilling and off loading of purse seiners/trawlers. This project has been developed together with fishing vessel owners and research institutes as Sintef. The project has been supported by Innovation Norge. There is a big hose reel on deck in order to make a safe and smooth handling of the suction hose, which is cutting out the normal hydraulic fish pump. This is also removing the risk of oil pollution in the hydraulic fish pump hoses. The fish hold to be loaded is always full of chilled water, and by pumping water from this hold, an under pressure is created. The under pressure is connected to the new design water separator, which is also connected to the suction hose. The water separator strains off the warm water coming together with the fish, and there is another water pump which is pumping this warm water over board again. This makes a steady and gentle flow of fish into the chilled fish hold at a capacity of some 500 tons per hour. Loading two fish hold simultaneously makes a total capacity of some 1000 tons per hour.

The new chilling design contains two holds only for sea water. From these holds, the RSW pumps sucks at optimal conditions always, and the water is pumped through the chillers and into the bottom of the fish holds. In top of the fish holds, a big area of strainers secure that the water over flows back to the water holds. The system is totally automatic and temperature sensors and flow meters always provide the optimal water flow for each fish hold.

Off loading is done by means of over pressure in the fish holds. Chilled water from the water holds is pumped to the fish hold to be discharged, and creating a flow of water through the off loading line. This water flow is transporting the fish in the most gentle way to the shore plant.

MMC is now making a project with Sintef in order to continue the chilled floating processes from the vessels to the shore plants. This includes a new receiving station consisting of two 30m³ stainless steel receiving tanks on the pier, under pressure loading and pressure off loading to the new grading machine. This makes a much simpler receiving system than the traditional today, and at a much lower maintenance and cleaning cost.

The new grading machine is based on vision techniques and will become the only machine which can grade such amount of fish individually and accurate. The machines are intended to make a capacity of some 40 tons per hour, and several machines can be installed in parallel in order to achieve the requested capacity.

The grading machine will replace the recourse weight and in give a lot of possibilities in order to make the traditional fish factories more simple.

MMC has decided to always use scientist institutes in R&D projects.

Fuel technology and energy efficient design and control on pelagic vessels

Ingve Sørfohn. Wartsila Ship Power Technology, Norway.

The maritime sector is a large part of the total global transportation system. There will be an increasing need for reducing emissions to air and execute more energy efficient operations for the whole industry. This will have strong influence on the design of vessels and the use of energy on-board. All aspects from ship design, propulsion, power generation, power distribution, operations and services have to be considered.

New energy sources like fuel cells and new gaseous engines will be introduced. Hybrid propulsion plants will be more attractive due to more flexible and energy efficient operations in emission controlled costal areas.

For the maritime industry the International Maritime Organization (IMO) has issued new regulations for NO_x and SO_x that will come into force the next years. The same organization has prepared proposals for reducing CO₂ by introducing energy efficiency plans and indexes and economical market instruments. These matters are in principle agreed and possibly put into force within short time.

Another important area is the expected future fuel cost that will require more efficient machinery systems and operations to support a sustainable business for the owners.

Indicators show strong interest in energy efficient systems and cost effective and reliable solutions. In general a more energy efficient operation will give a more sustainable business, but there are clear obstacles within financing new designs and investments in new technologies on short term.

New research and development programs will be necessary to demonstrate new machinery systems and a total understanding of energy use during different environmental conditions.

Is it sustainable to use fish as feed?

Ragnar L. Olsen. Norwegian College of Fishery Science, University of Tromsø, Norway.

Pelagic fish resources have been used for non-food purposes as industrial products and animal feed for more than a century. Today, most of the fish oil and meal available are used in compound feed for intensive aquaculture. It is however often said that it is not ethical correct or sustainable to use highly nutritional fish which could in theory be used for human consumption, as feed for fish and shellfish. The talk will focus on that use fish resources for feed is reasonable as long as the fish is legally caught from well managed stocks.

Effect of catching methods and on board handling systems on quality of pelagic fish

I.G. Aursand, H.Digre and I Martinez, SINTEF Fisheries and Aquaculture, Norway.

Although not widely studied, it has nevertheless been shown that catching methods and subsequent on board handling (Valdimarsson et al., 1984) may affect fish quality. Botta et al. (1987) compared the effect of season and catching method on the quality of cod (*Gadus morhua*) on muscle-pH, fillet colour, odour, discolouration/bruising and overall grades of cod. The results showed that catching methods had greater impact than season on

the quality of fresh cod. Hattula et al. (1995) studied the effect of gillnetting, poundnetting and trawling on mortality and quality of herring. Mortality increased when the trawling time increased from 2 to 5 h. Since rigor mortis started earlier with fish caught by gillnet, this indicated that gillnet was the most stressful catching method. Furthermore, muscle-pH is lower and the condition factor is generally higher of fish caught by gillnet compared with fish caught by longline (Esaassen et al., 2004). In the present study, the effect of the catching methods when using ring net (coastal vessel and ring net vessel) and trawling with traditional and T90 trawl nets, on quality of two different pelagic fish species; mackerel (*Scomber scombrus*) and Norwegian spring spawning herring (*Clupea harengus*), were evaluated. Fish quality was assessed according to mortality, external damages, initial muscle-pH, development of rigor mortis and visual assessment of fillet colour, texture and various blemishes (gaping, blood spots, bruising etc). The most pronounced effects on fish quality due to different catching methods were mortality rates and external damages. Trawling was the most stressful catching method for herring. Mackerel caught by the new trawl net (T90) had less external defects than those caught by the traditional trawl net. Moreover, mackerel caught by the T90 trawl net were generally of smaller size compared to traditional trawl. According to the fishermen, this was due to differences in capture time, i.e. time of the day. Smaller fish are commonly caught at night. A new design of a water separator on board a purse seiner was shown to give less blood-spots on herring fillets compared to a traditional designed water separator, indicating a gentler handling of the fish. Furthermore, a rapid method for measuring risk of belly bursting based on enzyme activity was presented. A web based quality manual (www.fhl.no/book) for the whole pelagic value chain from catch to market was presented. The manual is still under development, and will be completed and translated from Norwegian to English in year 2011.

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Advanced chilling techniques for pelagic fish – full scale results

Sigurjón Arason. Matis, Iceland.

The choice of the right cooling method and techniques for pelagic fish for processing good food products for human consumptions is important. Improved cooling techniques will also give better feed quality. With choice of cooling techniques must also take into account condition of fish, season variation of the difference fish species, quality criteria of raw materials, etc. Freshness of raw material is an important criterion of food products and fish-meal quality.

Potential fast and non-destructive methods to measure the fat in herring and herring products

Henrik Hauch Nielsen. DTU, Denmark.

The fat content is an important quality parameter for herring and herring products. The fat content varies throughout the season and follows the cycle of maturation and studies of commercial catches in Denmark show a considerable variation in fat content within the same catch. Furthermore it can be deposited differently in the tissue depending on the maturation status of the herring.

Several methods are applicable for measuring the fat content in individual fish in a non destructive way and can have potential as at-line or on-line measurement of fat. In the Danish research project “Herring – A living resource – A good product” carried out at the former Danish Institute for Fisheries Research, Division of Seafood Research from 2001 to 2005, three methods were studied: Near InfraRed (NIR), Nuclear Magnetic Resonance (NMR) and the Fatmeter. The objectives were to investigate their correlation to a chemical reference analysis and to evaluate their suitability as future quick non-destructive methods for measuring the fat content in herring.

The results confirm the wide variation in fat content within each catch with fat contents ranging from 1 to 25%. The results furthermore show that NIR, NMR and Fatmeter have different suitability and applicability as fast non-destructive methods for determination of fat content. The Fatmeter measurements were highly influenced by gonad maturity and are therefore not suitable for measurements on whole herring. NIR measurements gave good predictions with low prediction errors and thus show high potentiality as a fast and non-destructive method for measuring fat content in a production line. Also NMR gave good predictions but as measurements were done on minced herring, further work on whole muscle is necessary before a final evaluation of the suitability of this method can be done. In the Nordic Innovation centre (NIC)-funded project SILLQUID, the fast and non-destructive method microwave (MW) dielectric spectroscopy, developed in two recent EU-projects, was tested for prediction of fat of a unique herring material collected and analyzed during another NIC-funded project “Improved quality of herring for humans” and also tested during industrial production of herring and mackerel fillets. The MW tool was able to detect fat content of pelagic fish, at least up to fat levels of 18% (herring) or 25% (mackerel).

Session 4

Socio-Economic Return of Pelagic Fisheries in the Northeast Atlantic Ocean

Max Nielsen, Peder Andersen, Jesper Andersen, Lars Ravensbeck, Frederik Møller Laugesen, Daði Már Kristófersson, Siv Reithe, Jon Nilssen and Hans Ellefsen.

*“There are too many fishermen to fish too few fish”. This is the case in many fisheries. The consequence is that fishermen have low income, that the industry does not contribute to the national economy, that the public sectors costs of the industry exceeds revenue, and that supplies of fish are lower than it otherwise could have been, and at a higher price. That is the reason for the intensive focus on improving fisheries management worldwide. World Bank and FAO (2008) assesses in the report „*The Sunk-en Billion*”, that the socio-economic returns in fisheries globally is negative. Thus, the costs of society of the existence of a fishing industry exceed revenue, which implies that the world’s fisheries from a narrow cost-benefit consideration should be shut down. Several studies estimate that maximum socio-economic returns of 40-50% can be achieved by good management (Nielsen et al 2006, World Bank and FAO 2008).*

The present study is a contribution to the debate about how much the society can achieve in economic return of fisheries managed in accordance with a socio-economic objective. It focuses on pelagic fisheries with large vessels in the Northeast Atlantic Ocean, that is, fishing of mackerel and herring (Norwegian spring-spawning herring and North Sea herring) and the fish species used for reduction blue whiting, capelin and sand eel. Large vessels from Iceland, Norway, Faroe Islands, Denmark, United Kingdom and to a minor extent Russia is included. These fisheries have for years been well managed economically and can be viewed as „*best practice*”. Individual transferable quotas are used in Iceland, the Faroe Islands and Denmark. Individual non-transferable quotas are used in Norway and the United Kingdom, where quotas implicitly are traded together with the vessel, implying that management in the two countries to some extent works like pure individual transferable quota systems.

The purpose of the study is to analyze how much well-managed and efficient fisheries, as the pelagic fisheries in the North East Atlantic Ocean, contributes to the socio-economy, and, to assess how the socio-economic returns possible can be increased through improved fisheries management. Furthermore, the purpose is to identify who benefits, how and to what extent it is possible to redistribute returns from the industry (owners of vessels and quotas, and crew) to the society. The desirability of redistribution is not assessed.

The socio-economic return is defined as „*the surplus remaining after remuneration of capital and labor in excess of remuneration obtained in other businesses*“. The socio-economic return is measured with and without deduction of public expenditures on fisheries, including fisheries management costs and subsidies. The socio-economic return without deduction amounted to DKK 1.9 billion in 2007, or an average of 32% in the five vessel groups (Russia excluded), highest in the Icelandic vessel group with 43% and lowest in the Danish with 17%. The socio-economic returns after deduction amounted to an average of 26%.

The socio-economic returns are volatile in 2000-2008, but develop similarly across countries. The developments appear mainly from fluctuations in prices and fish stocks. The return is highest at the end of the period, lower in the beginning, and smallest in 2003-2004. The low yield in 2003-2004 is mainly due to low prices on herring and mackerel. The return of the five countries is stable or slightly rising. The socio-economic return in the Danish vessel group increased due to the in 2003-2007 introduced individual transferable quotas.

The maximum socio-economic returns in the long run are calculated in a bio-economic model with a series of assumptions about biology, economics, fleet structure, fisheries exploitation patterns and capacity utilization. With unchanged capacity utilization, the maximum socio-economic return, given that the quota allocation among countries remains unchanged, is on average 40% of the landing value. This represents an increase of 8%; Largest in Denmark with 23%, smallest in Norway where the return remains unchanged. If the quotas could be traded freely among individual vessels from different countries, corresponding to that the most efficient vessels purchase quotas from the less efficient, the maximum socio-economic return increase to an average of 43% of the landing value. If capacity utilization can be increased to 350 days for Icelandic vessels, to

300 for Faroese and to 250 for the others, corresponding percentages are 45% and 48%, respectively. At an unchanged quota allocation among countries, this corresponds to an increase of 14%; Largest in the United Kingdom with 29%, smallest in Iceland where the return remains almost unchanged. Which capacity utilization is realistic should be assessed knowing that some management systems limit flexibility and that some fisheries are seasonal. The maximum socio-economic return is estimated to lie somewhere between the two extremes.

The high current return reflects relatively efficient management of the analyzed pelagic fisheries. The fisheries policies emphasize socio-economic return, thereby giving less room for other possible purposes of the fisheries policies. The calculation also shows that there is scope for increasing the return through improved management, both nationally and through closer international cooperation. The largest increase can be achieved with improved national management (8-14%), where the increase with closer international cooperation is modest (3%). There is not assessed to be significant opportunities for improving fisheries management in countries with individual transferable quotas, i.e. Iceland, the Faroe Islands and Denmark. Additional gains may be achieved over time in Denmark and the Faroe Islands, without changing management, since the management there is relatively new. In Norway and the United Kingdom the flexibility of management can be enhanced by making quotas fully tradable, both permanently and temporarily, without vessels simultaneously being traded. The socio-economic returns are also estimated to increase slightly through closer international cooperation, which allow individual vessels from the different countries freely to trade quotas.

The distribution of the socio-economic returns in 2007 between the owners of the vessels and quotas, the crew and the public sector indicates, that public authorities on average achieves 11% of the socio-economic returns. The public sector share is positive in all countries, Denmark excluded; Largest at the Faroe Islands with 21%, at smallest in Denmark with -18%. The negative public share of the socio-economic return in Denmark corresponds to that tax revenues are less than public expenditure on fisheries management and subsidies for that vessel group.

The crew obtains an average of 38%. The crew share appear from salaries being from 85% higher than for the same number of hours worked in other businesses (Iceland and Denmark) to almost four times as high

(United Kingdom). Part of the explanation for the higher salaries is the disadvantage of being at sea for long fishing trips, where the crew can work up to 12-14 hours a day.

Owners will have the remainder of the socio-economic return (on average 52%); Highest in Denmark with 74% and smallest in Norway, with 40%. The current owners *can* have a substantial income from fishing. However, it might not be the case when the current owners have purchased quotas from former owners. Provided that they have paid the full price to the former owners, the owners' share of the socio-economic return have been given to previous generations of owners and removed from the industry. This is the case in countries where management has been in force for several years (Iceland, Norway, United Kingdom and partly the Faroe Islands). In Denmark, the present individual transferable quota system was introduced as late as in 2003-2007, implying that most of the income is estimated to be allocated to the current owners.

Improved fisheries management increases the socio-economic returns and with that the owners share. Whether the increases accrue to the current or previous owners depend on, whether the improvement was expected. Provided that it was expected, higher quota prices had appeared and the former owners receive the increase in the socio-economic return. If it was surprising, the increase accrues to the current owners. The crew will also obtain a part of the increase, if salary schemes remain unchanged. In the long run there will be fewer vessels and, thereby, less crew to share a fixed proportion of an increasing landing value. This gives the crew, who remain active, higher salary.

With improved conditions for both owners and crew, tax revenues increase together with returns. The public sector share is, however, in several cases negative in bad years. That is, even though the Fisheries Law in several of the countries owning pelagic stocks states that the society owns the fish stocks, the public sector share of well-managed pelagic fish stocks are at best 1/5 and on average 1/10 of the socio-economic returns. In bad years the cost of management and subsidies exceed the tax revenues.

On this basis, the possibility of redistribution to the public sector is analyzed. If redistribution is desirable, it should necessarily be assessed together with efficiency. The reason is that when the management has been in force for long time, as in several of the pelagic fisheries, redistribution does some fishing vessels unprofitable, forcing efficient fishermen

to leave the industry. The reason is that the return have been pulled out of the industry, since the current owners have paid the previous owners for their quotas. Thus, there is a trade-off between size and distribution of the socio-economic returns. If distribution changes, return can declines. Declines in socio-economic returns as a result of redistribution can be avoided by applying the principle "*the socio-economic returns can only be redistributed from those who have had it granted*", thus limiting the possibility of redistribution to situations where the socio-economic returns are rising. That could either be as a result of improved fisheries management, as in the Danish pelagic fishery, or due to external factors such as price increases or improvements of fish stocks.

The socio-economic returns can be redistributed to the society through user fees and extra taxation. User can, for instance, be introduced through the removal of favorable arrangements for fisheries, including subsidies and fishermen deductions, by recover costs of fisheries management and through the sale of fishing rights at auctions. For instance, through reservation of a fraction of the total annual quota, which are subsequently sold at auction. Taxation instruments include taxes on landings, returns and on ownership of fishing rights.

Iceland is an example of a country that already has an extra tax on owners' returns. The experience is, however, that the charge has only charged a small part of the socio-economic returns. The reason is that there have been individual transferable quotas for many years, leading to that a large proportion of returns are in the hands of previous owners and are therefore not in the fishing industry anymore. The possibility of further redistribution without affecting efficiency is thus limited to a situation where the socio-economic return increase as a result of, for example, price increases and improved fish stock conditions.

Denmark introduced recently, in 2003-2007, individual transferable quotas. With the recently changed management system the option of introducing redistribution through user fees on fish resources is present without vessels become unprofitable. But as time passes and the quotas are traded, the option diminishes. Conversely, according to the Fisheries Law, the management can always be terminated by notice eight years in advance, implying that an announced redistribution is always possible.

The Faroe Islands is to review the fisheries policy in 2018, which allows for redistribution. In Norway and the United Kingdom, the manage-

ment has been in force for long time and the possibility of redistribution is limited to when the socio-economic returns are rising. Redistribution can, for example, be introduced simultaneously with that the flexibility of the quota system is increased by allowing sale of quotas, both permanently and temporarily, without simultaneous sale of the vessel.

It is emphasized that the findings in this report are based on a number of assumptions, both in relation to size and distribution of the socio-economic returns, and in identifying the maximum socio-economic returns. The results are therefore uncertain and should be interpreted with caution.

Lost rents, sunken billions

Ragnar Arnason. Department of Economics, University of Iceland.

Many fish resources are potentially extremely valuable. Estimates conducted by the World Bank and FAO (2009) indicate that pure profits from the global commercial fishery could be well above 50% of the landed value. If this is correct, commercial fish resources can be even more valuable per unit of output value than most oil reserves. It follows that societies holding significant fish resources are in a position to reap great economic benefits.

Unfortunately, the very substantial economic gains offered by fish resources do not happen automatically. To realize them, the fishery has to be conducted in the appropriate way. In particular, the traditional common property arrangement of ocean fisheries virtually guarantees that no net economic benefits will be obtained. The fundamental reason is lack of individual property rights in the harvest or the fish stocks themselves. Without such property rights, there can be no prices and, therefore, no market guidance toward the socially optimal fishery. If, on the other hand, sufficiently strong property rights, such as individual quotas (IQs) or territorial user rights (TURFs) are employed, both theory and experience show that the fishery will quickly start to generate net economic benefits.

In a study of the economic of the global fishery conducted 2006-9 by the World Bank and FAO, it was found that far from contributing substantially to the global economy, the world's fisheries in 2004 were actually run at an economic loss amounting to some 5 billion US\$ annually (Figure 1). Interestingly, this loss was not suffered by the fishers themselves. It

was covered by subsidies from several generous governments of the world, primarily those of Japan and the European Union. In stark contrast to this actual loss, the potential economic profits from the global fishery was estimated to be about 44 billion US\$ annually (Figure 1). Thus, the total economic waste in the global fishery caused by fisheries mismanagement was estimated to be about 50 billion US\$ annually. This is a substantial amount of money. It is not much less than the total development assistance from rich nations of the world to the underdeveloped nations. It would suffice to double the income of the 500 million of the poorest inhabitants of this world.

Figure 1: The global fishery (World Bank and FAO 2009)

The good news is there are now clear signs that the long term decline in fish stocks and the net economic benefits in the world's fisheries is slowing down and even, in several cases, reversing itself. Some important fish stocks are on the mend and the fishing industries of some nations are now turning healthy and growing profits. This is primarily happening in na-

tions which have adopted ITQs and ITQ-like systems in their fisheries. With regard to these fisheries management systems, there has been a dramatic change over the past three decades. From virtually no ITQs in 1980, at least 22 fishing nations around the globe have now adopted ITQs in their fisheries. There are probably close to a 1000 individual ITQ fisheries in the world and about 25% of the global ocean fish catch is taken under ITQs or ITQ-like fisheries management systems.

The pelagic fisheries of the world are generally much less profitable per unit output than their demersal counterparts. This applies not the least to the pelagic fisheries of the North Atlantic which are dominated by comparatively low-priced species such as herring, blue whiting and mackerel. Due to their large stock sizes and high catch volume, these fisheries are nevertheless potentially very valuable. To realize these potential economic benefits, the pelagic fisheries must be guided by the appropriate management regime. This is made more difficult by the trans-boundary migratory behaviour of these stocks and by the inherent instability of their migratory patterns and stock abundance. An additional looming problem is the role of these pelagics in the wider marine ecosystem as prey of more valuable species and competitors of others.

Session 5

Economics of Allocating Transboundary Fish Stocks

R. Quentin Grafton. The Australian National University.

The presentation reviews the current state of the world's five tuna regional fisheries management organizations (RFMOs) and shows that, despite adopting different approaches, have failed to prevent overcapacity and, for some stocks, overexploitation. The presentation argues for an incentive-based approach that would be in compliance the United Nations Fish Stock Agreement and would allocate permanent catch shares of the Total Allowable Catch (TAC) to member countries defined by species and spatially. Annual allocations of quota based on the current TAC, but not permanent country shares, could be traded. Annual allocations could assist in negotiations and „side-payments” to ensure agreement over the permanent country shares. A small percentage of the total could also be sold to fund monitoring, compliance and surveillance by the RFMO.

The (lack of) law on allocation of straddling and highly migratory stocks

Andrew Serdy, School of Law, University of Southampton, UK.

I'm afraid I come as the bearer of sobering news. The original title of the paper in the slot I am now filling was to do with FAO and other international recommendations on allocation of straddling and highly migratory stocks, but in fact there are no UN-level instruments on allocation generally; the closest one gets is Article 11 of the 1995 UN Fish Stocks Agreement,¹⁴ which I will shortly come to; nominally directed only at States newly entering an already existing international fishery, but possibly capable of wider application. So, much as I wish I could take up the challenge

¹⁴ Agreement for the Implementation of the Provisions of the United Nations Convention on the law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (New York, 4 December 1995), 2167 UNTS 3.

to advise on how the law can instantly solve allocation problems, the best I can offer is some thoughts on procedures that could more or less force States to succeed in solving them for themselves.

In the past this question defeated no less than one of the law of the sea greats, Judge Oda who served for many years on the International Court of Justice, and he admitted as much at the 1967 conference of the Law of the Sea Institute.¹⁵ The only thing I can add is that in retrospect it's no surprise that even such an eminent jurist could confess himself at a loss because, in terms of the classical principles of international law, notably the high seas freedom of fishing, it does indeed appear to be insuperable in substance – a classic who-gets-what, i.e. political, question. 16 years later, in the context of more general criticisms of the drafting of the fisheries provisions of the 1982 United Nations Convention on the Law of the Sea¹⁶ or UNCLOS, which has become the central instrument of the modern law of the sea since its entry into force in 1994, Judge Oda speculated on the consequence of their failure to deal with the question of allocation. This, he thought, was that sooner or later high seas fisheries would have to be brought under the same type of regime as Part XI of UNCLOS had just instituted for the mineral resources of the deep sea-bed, where an internationalised mining regime is administered by the International Seabed Authority.

That is less a solution than an escape – to give up in despair, or redefine the problem, if you prefer, and hand the question and responsibility of ownership or at least management of stocks to an international authority in which States pool their rights in respect of them. Thus one could imagine the authority instructed to maximise the fishery's long-term economic return and by allocating catch or effort quotas to individual operators regardless of nationality. But since there's no single organisation competent to administer all international fisheries, you would also have to decide what to do with the many already existing regional fisheries management bodies that the Fish Stocks Agreement supports by requiring States fishing for the

¹⁵ S. Oda, "Distribution of Fish Resources of the High Seas: Free Competition or Artificial Quota?", in L.M. Alexander (ed), *The Law of the Sea: The Future of the Sea's Resources: Proceedings of the Second Annual Conference of the Law of the Sea Institute*, June 26-29, 1967, the University of Rhode Island (Kingston: University of Rhode Island, 1968), p. 29.

¹⁶ Montego Bay, 10 December 1982; 1833 UNTS 3.

stocks they cover either to join them or to cooperate with their management measures. And, short of a dramatic collapse of several stocks in quick succession, I don't think this is realistic – for all the difficulties they have with the allocation process, States as the middlemen in charge of it are unlikely to want to give up that role. Besides, like the RFMOs the authority would still have the problem of non-member fishing to deal with, because it would have to be created by treaty, which binds only those States that choose to become party to it.¹⁷ True, the more parties a multilateral treaty attracts, the more it exerts over time what's been called a “gravitational pull” on the pre-existing customary international law, so that even non-parties become bound – not by the treaty as such, but by some or all of the substantive rules within it¹⁸ – but that process is only gradual and far too slow to prevent the emergence of non-member problems. That's worth a presentation in itself but isn't what I'm here to talk about today.

So that brings us back to UNCLOS. Freedom of fishing remains guaranteed on the high seas by UNCLOS Article 87 [SLIDE 2], but this is no anarchy in which States or fishing vessels can act as they please; rather, States must exercise their freedoms with due regard for the like exercise of freedoms by other States.

In the drafting of the Ministerial declaration at the 2005 St John's conference, [SLIDE 3] which in the end pledged to use allocation criteria that give something to everyone but twice mention developing States, I recall hearing a major player who should have known better say that UNCLOS is completely even-handed as between coastal and distant-water fishing States. That is only half-true. It's true on the high seas, but neglects the exclusive economic zone or EEZ. By Article 116(b) of UNCLOS, which you now see [SLIDE 4], the right of all States to fish on the high seas is subject

¹⁷ This rule, sometimes called the *pacta tertiis* principle after the Latin maxim *Pacta tertiis nec nocent nec prosunt* (treaties neither harm nor favour third parties) is found in Article 34 of the 1969 Vienna Convention on the Law of Treaties, 1155 UNTS 331, and, like most of that convention, represents a codification of the pre-existing customary law regarding treaties.

¹⁸ M.H. Mendelson, “Fragmentation of the law of the sea”, (1988) 12 *Marine Policy* 192 at 199. Some treaty provisions, particularly technical and procedural ones, can never enter the realm of custom. The general rule as expressed by the ICJ in the *North Sea Continental Shelf case (Federal Republic of Germany/Denmark; Federal Republic of Germany/Netherlands)*, ICJ Reports 1969, p.3 at 41-42 (paragraph 72) is that only those provisions can do so which are “of fundamentally norm-creating character” and thus capable of forming the basis of a general rule of law.

to the rights, duties and interests of coastal States fishing in their EEZs for straddling stocks and highly migratory species. That falls short of absolute priority for coastal States – after all they are still reliant on distant-water States’ cooperation on the high seas and the duty to cooperate is mutual – but it does mean that coastal States can legitimately claim some sort of preferential treatment for their in-zone fisheries.

But there’s no agreement on what that means in practice. The only guide we have is Article 11 of the Fish Stocks Agreement which you now see on screen. [SLIDE 5] The first thing to notice is that it’s expressed to apply only to new members, but the second thing is that, despite this, the factors listed are exactly those that coastal and distant-water fishing States have been making for decades in arguments with each other on fair allocation of stocks. So all the law is really is saying is that the standard arguments on either side, the ones you’re no doubt wearily familiar with, are all valid and all to be taken into account – and gives no clue as to whether any of them should be given more weight than others, and if so which ones and how much.

So States just get on with it as best they can – is there anything to be learnt from how their attempts to grapple with the problem in commissions have fared? We can leave aside the rather unedifying story of the Northwest Atlantic Fisheries Organisation in the early 1990s, more a lesson in what to avoid. I know of only one major exercise of sustained attention, the Atlantic Tuna Commission (ICCAT)’s Working Group on Allocation, which over several meetings from 1998 eventually produced a long elaboration of Article 11 in its 2001 Allocation Criteria.¹⁹ After that there were faltering attempts in the Western and Central Pacific Tuna Commission to discuss it, which have never really got off the ground – a report was commissioned from consultants which you can find on the WCPFC website, but almost immediately put in the too-hard basket where it remains, and something similar is promised for 2012 in the Southern Bluefin Tuna Commission, which will be good if it happens but I’m not holding my breath. So the ICCAT Allocation Criteria are all we have to work with.

¹⁹ “ICCAT Criteria for the Allocation of Fishing Possibilities” (Annex 8 to Proceedings of the 17th Regular Meeting of the International Commission for the Conservation of Atlantic Tunas (Murcia, Spain - November 12 to 19, 2001)), in ICCAT, Report for biennial period 2000-01 Part II (2001) - Vol.1, at p. 211.

The Working Group was set up because many members and observers were unhappy with ICCAT's practice of allocating purely on the basis of catch history, ignoring the new factor of the EEZ. An example is Atlantic bluefin tuna: in the mid-1990s Iceland suspected the presence of this species in its EEZ, and was considering developing a fishery for it and joining ICCAT, but worried that its rules might prohibit new members from targeting bluefin, even in their own EEZ and irrespective of the stock's distribution – which ICCAT did not deny. By 2000 the situation had not changed. Iceland told that year's ICCAT meeting that until the allocation system was reformed, it would remain only an observer.

ICCAT's correspondence with Iceland and other coastal States made the point that leaving each to decide for itself how much it catches would frustrate proper management of the stock. That's true, but does not answer coastal States' objection that joining ICCAT would not automatically entitle them to any quota, let alone one equitably reflecting their preferential status under UNCLOS Article 116(b). For instance Namibia complained that allocating on catch history was inconsistent with coastal States' rights under UNCLOS and especially the Fish Stocks Agreement. This was unacceptable because it had no opportunity in the past to participate in fishing.

Other drawbacks of overreliance on historic catch are that it punishes past cessation of fishing, whether voluntary or not. Involuntary cessation, by which I mean withdrawal from a fishery because of falling catches due to overfishing mainly by others, may then be an obstacle to the coastal State's re-entry when things improve, for example, Norway's tuna fisheries ceased in 1986 when the yearly migration into its waters failed, but by 1998 the stock was again present off neighbouring States. Nor would it be wise to discourage voluntary cessation of fishing; this reinforces the tragedy of the commons, by permitting those States that keep fishing to use their subsequent catch history to their own advantage.

Japan admitted that the historic catch criterion disadvantaged newcomers, but said reallocation would be inequitable. The Europeans were the last to abandon the view that, for stocks already allocated, historic catch should be the only criterion, a stance opposed by developing States, but ultimately gave way. The opposing idea that the spatio-temporal distribution of a stock's biomass should govern the allocation was supported by Brazil and Namibia but rejected by Canada, the EC and Japan on the unconvincing ground that this would result in scientists making the allo-

cation. Mexico, Norway and Iceland argued that coastal States with stocks in their EEZs must have a right to them, but the United States, supported by France and Japan, said ICCAT should not have to distribute resources to non-members just because they were coastal States. If they wanted quota for species managed by ICCAT, the onus was on them to join; there would be no point to ICCAT if coastal States could simply fish the stock. South Africa in response made the obvious point that ICCAT should avoid depriving coastal States of all incentive to work within the system.

There's more, but eventually agreement was reached and the Working Group was able to present a consensus text to the plenary with 18 allocation criteria instead of six and nine provisions on their application. Yet these criteria are a job only half done. Although for Iceland, they "changed the situation, making it possible ... to join ICCAT in the expectation of getting our fair share of the fisheries", they contain no arithmetical formula for allocation, but leave these to be worked on out on a stock-by-stock basis, for which they give only general guidance. There seems to have been no recognition that the legal and political issues would not be finally resolved until the various factors were given some concrete numerical expression – set weightings or even just as maxima or minima.

As if to confirm that this issue was far from settled despite the agreement on criteria, ICCAT deferred applying them to the western stock of Atlantic bluefin tuna, deciding that meanwhile the allocation in the 1998 rebuilding programme would continue. Similarly the Europeans said that for South Atlantic swordfish "automatic transfer of quotas was not feasible at this time". ICCAT completely failed to come to grips with the allocation of this stock: a TAC was set but left undivided, and the parties fishing it were asked to set their own quotas so as not to exceed the TAC.

Like problems have continued to plague allocation of the eastern stock of Atlantic bluefin tuna. In 2003 Turkey, Mexico and Morocco called for application of the 2001 criteria to allow new members a share of quota. The US agreed that "expectation of receiving quota is an incentive for new members to join ICCAT and take part in its conservation and management programs." But Japan didn't want to change the multi-year plan in force and the EC argued that allocations to new members should come out of the previous "others" share, which Turkey complained would be a disproportionate burden on non-members and a disincentive for them to join ICCAT. So not much has really changed.

I don't have time to discuss the elaborate policy statement on the application of the 2001 Allocation Criteria tabled by South Africa or the considered response to it by Taiwan, which accepts a falling share as long as economic dislocation of its fleet is minimised. While there's a basis in this exchange for rational resolution of the issue, the matter has not moved forward, and one of the recommendations from the 2008 external performance review was that "ICCAT should develop binding allocation criteria ... applied in a fair and transparent manner." That's a less than ringing endorsement of the non-binding and often vague 2001 Allocation Criteria as implemented to date.

Finally, there was also a chapter on allocation in the Chatham House „best practice“ report of 2007,²⁰ [SLIDE 6] which takes the same line I have – this is basically a political not legal issue which tends to get bogged down on the non- or new members question – but offers a few commonsense tips. First, no State should be made worse off by cooperating over its allocation than it would be through competition if the stock were unregulated in bioeconomic equilibrium. Secondly trading of allocations may be another way out rather than a comprehensive solution – have an almighty row about initial allocations, but once that's settled leave States to adjust their shares by voluntary private and transparent transactions rather than renegotiate them each year. Thirdly, historic catch is not a good basis for allocation in anything but the very short term. Fourthly, developing States are entitled to some preference, although again no one knows precisely what that means. Fifthly, there should be dissuasive consequences for exceeding allocations (I recently wrote an article on this²¹ which concluded that too often there are none). Sixthly, the allocation process should be transparent to instil confidence in it, and lastly, even after you have got all of that right, you need to build in flexibility in case the physical world changes, for example warming seas push stocks out of one State's EEZ into another's, or onto the high seas, or *vice versa*.

²⁰ M.W. Lodge, D. Anderson, T. Løbach, G. Munro, K. Sainsbury and A. Willock, *Recommended Best Practices for Regional Fisheries Management Organizations* (London: Chatham House, 2007), Chapter 4, "The Allocation of Rights".

²¹ A. Serdy, "Accounting for Catch in Internationally Managed Fisheries: What Role for State Responsibility?", (2010) 15 *Ocean and Coastal Law Journal* 23.

So law doesn't simply disappear from the picture, for legal policy, which is what much of the Chatham House list is, should not be overlooked.

Procedurally too, through the availability – where it exists – of compulsory dispute settlement, law has an important role to play in giving competing parties an incentive to reach political agreement. This isn't because I think judges and arbitrators are the best people to divide up TACs – I cheerfully admit they're not – but the very fact that Article 7 of the Fish Stocks Agreement allows any party to seek an allocation through the dispute-settlement process gives all parties cause to moderate their demands lest they lose control of the allocation to unpredictable judges. This has only happened twice that I know of, both times as provisional measures pending a decision on the merits of the broader dispute – the *Fisheries Jurisdiction case* between Iceland on one hand and the UK and Germany on the other in the 1970s,²² and the 1999 *Southern Bluefin Tuna* case pitting Australia and New Zealand against Japan.²³ Neither solved the problem in itself, but both helped the parties later reach agreement on their own. So threats to invoke Article 7 could be a most useful tactic for States that think their opponents are intransigent, but probably only if they are really prepared to act on the threat if needed. The fact that in the nine years since the Fish Stocks Agreement came into force there have been no such disputes (or at least none that weren't settled early enough to avoid becoming publicly known) – a sign that this provision is largely working as intended – is the most positive note I can think of on which to end.

²² *Fisheries Jurisdiction* (United Kingdom of Great Britain and Northern Ireland v. Iceland), Interim Protection, Order of 17 August 1972, ICJ Reports 1972, p.12.; *Fisheries Jurisdiction* (Federal Republic of Germany v. Iceland), Interim Protection, Order of 17 August 1972, ICJ Reports 1972, p.30.

²³ *Southern Bluefin Tuna Cases* (New Zealand v Japan; Australia v Japan), Provisional Measures, Order of 27 August 1999, ITLOS Reports 1999, p.280.

Coastal States Arrangements. Blue whiting, Herring, Mackerel, Capelin.

Eskild Kirkegaard. National Institute of Aquatic Resources, Technical University of Denmark.

Four coastal State arrangements exist in the northeast Atlantic for the management of the fisheries on the highly migratory pelagic stocks of Norwegian spring-spawning (Atlanto – Scandian) herring, Northeast Atlantic mackerel, Northeast Atlantic blue whiting and capelin in the waters between Greenland, Iceland and Jan Mayen. The arrangement on capelin is in the form of an official multiannual agreement between the coastal States. The three other arrangements are informal in the sense that they are formulated as annual recommendations and not as official agreements. Independent of the formal setup the arrangements play a central role in the management of the pelagic fisheries in the northeast Atlantic by being the forum for setting the TACs for the stocks concerned and the sharing of the TACs between the parties. The coastal States arrangements constitute the basis for NEAFC recommendations for fisheries in the NEAFC regulatory area and for bilateral arrangements and unilateral measures on the management of the stocks. This means that if the coastal States fail to reach an agreement on a management arrangement there will be no joint management of the fisheries concerned.

The coastal States arrangements include in general 1) a long-term management arrangement (LTM) in the form of harvest control rules specifying how to set the TAC; 2) the TAC for the coming year defined in accordance with the LTM and the allocation of it between the parties; 3) joint control initiatives and 4) joint statements on research.

The LTMs for herring, mackerel and blue whiting include harvest control rules setting the TAC consistent with a target fishing mortality. The target fishing mortality is defined as a function of the stock size developed on the basis of single species considerations. The use of stock size as the key parameter for setting the target fishing mortality may not necessarily be optimal in ensuring that abiotic as well as biotic changes in the ecosystem are taken into account and addressed in the management decisions. There may therefore be a need to rethink the harvest control rule concept used in the LTM to ensure that ecosystem considerations are addressed appropriately in the coastal States arrangements.

The Pelagic Complex

Kjartan Hoydal. General Secretary of NEAFC.

States cooperate in Regional Fisheries Management Organisations, RFMOs to establish fisheries management systems in the high seas supporting and compatible with systems in sea areas under national jurisdiction. At the 2006 UNFA Review Conference cooperation through RFMOs was seen as the major vehicle for sustainable fisheries management. This was further underlined at the resumed Review Conference May 2010.

The objective of the NEAFC Convention, as updated in 2006 is to ensure the long-term conservation and optimum utilisation of the fishery resources in the Convention Area, providing sustainable economic, environmental and social benefits. In Article 4 NEAFC in 2004 acquired a conservation mandate in addition to the fisheries management mandate in line with the UN Fish Stock Agreement.

In the NEAFC Fisheries Status Report annual Landings from the pelagic complex were estimated around 3 million tonnes with a landing value estimated around 600 to 7000 million US\$.

The Contracting parties have been able to agree on the allocations in the pelagic stocks, albeit these agreements have regularly broken down, blue whiting 2003-2005, Norwegian spring spawning, (Atlanto-Scandian) herring 2003-2006 and there is no agreement on allocations of mackerel for 2010.

This shows the “wicked” problem of allocation. International law and instruments are very firm on a number of issues, but there is no international agreement on how to solve problems of allocation.

Who Gets What? Lessons from 20 years of Negotiations over Straddling Fish Stocks in the North Atlantic.

Áslaug Ásgeirsdóttir. Bates College, USA.

Norway and Iceland, along with other nations, signed seven agreements allocating fishing rights to four different straddling fish stocks in the North Atlantic between 1980 and 1999. The Icelandic-Norwegian capelin stock has been collectively managed since 1980. In the 1990s, the countries reached agreements to manage Atlantic-Scandinavian herring (also known as Norwegian spring-spawning herring), oceanic redfish and the

Barents Sea cod stock. These agreements are purely distributive in nature, i.e. they allocate a preset Total Allowable Catch (TAC) among states party to the negotiation. However, the allocation of these four stocks amongst the negotiating partners – i.e. who gets what – varies across stocks and over time. The empirical analysis of these seven agreements reveals the centrality of politics in the negotiating process, evident by relying on historical rights when allocating straddling stocks, and how domestic interest groups influence the choice of baselines in the negotiations. Specifically, this analysis provides an answer to the question of what factors constrain the ability of negotiators make and accept offers, and how these constraints can advantage and disadvantage the states involved and thus influence the distributional outcome of the negotiations.

Is Game Theory Possibly a Method for Solving the Allocation Problem?

Rögnvaldur Hannesson. Norwegian School of Economics and Business Administration.

The answer to the question is yes, with some caveats. First, what does game theory do? The name itself is a bit unfortunate, as it might convey a lack of seriousness – playing games has a connotation of something unworthy. The theory of strategic interaction would be a more appropriate name for what has come to be known as game theory. It applies to situations where the actions of one individual or firm has an appreciable effect on others, such as when a limited number of agents exploit a common resource, produce similar products, or sell similar things in the same market. In such situations each player will take into account the consequences of other players' decisions when he makes his own, including how they might react to a particular decision by him. This is in contrast with what has come to be known as perfect competition where there are so many agents that the actions by one have negligible effects on others. That does not preclude that the sum of all actions will indeed have an effect on the outcome for each and for all taken together, but the actions of one single player are too insignificant to induce any reaction by other players.

There are two basic options available in the strategic interaction case. The players can either cooperate, or each can try to achieve what is best

for himself, given the actions of all others. The typical situation is one where the actions of one player have negative effects on the others – more fishing by one country typically means less fish available for all in the future and possibly also more costly fishing; lower price charged by one seller steals customers from others; a better product made by one means less demand for „traditional“ products made by others. An outcome that maximizes the sum of gains for all therefore requires cooperation. Absent cooperation, each player will take into account how others would react to his decisions and will try to maximize his individual gain, given the reactions of others. This is the non-cooperative solution.

Game theory can contribute to achieving the cooperative solution by clarifying what each individual player would obtain in a non-cooperative solution. No individual, country or company will accept an outcome that is not at least as good as the non-cooperative outcome, unless there is some external coercion imposing a solution. National governments can force their fishermen to abstain from fishing or ban price fixing among their companies, but there is no such coercive force constraining sovereign states. Hence game theory delineates what there is to bargain about; it will not lead anywhere to offer a sovereign state a smaller fish quota than what it would take on its own in the non-cooperative solution.

This delineation of the bargaining space usually leaves a substantial leeway with respect to what can be offered to a single player, say fish quotas for individual countries. Game theory has come up with several refinements with respect to what the solution should be – the Nash bargaining solution, Shapley value, and others. Despite their theoretical attractions I know of no situation where these concepts have been applied to achieve a cooperative solution and so I will not consider them any further. In this sense game theory is insufficient to solve the allocation problem; this is likely in practice to be left to some rough and ready bargaining among countries without much guidance by axioms which the outcomes might be required to satisfy on theoretical grounds. Suffice it to say that all parties will have to make some gain compared with what they would get in a non-cooperative outcome, and that the distribution of the gains will have to be considered fair, even if in a rough and ready way.

Let me illustrate with a simple fishery example. Suppose there is a fish stock S that always appears in the beginning of a fishing season, independent of how hard it has been fished (this obviously ignores population

dynamics, the incorporation of which would only complicate the example without changing the conclusions qualitatively). If the stock is left to grow until the end of the fishing season, more fish could be caught. If the stock is shared by two or more countries, this would require that they abstain from fishing at the beginning of the season. To make the example more striking, suppose one nation can catch the entire stock if it does so at the beginning of the fishing season. Ignoring costs, we would have the following payoff matrix in the two-player setting (first number in each cell is Player 1's payoff):

		Player 2's strategies	
		Cooperate	Don't
Player 1's strategies	Cooperate	75, 75	0, 100
	Don't	100, 0	50, 50

Here I have used numbers such that the stock always emerging is 100, and would grow by 50% if left alone to the end of the fishing season. But the best reply of each player to the decisions by the other is always to fish immediately; if one player waits, the other player can get 100 instead of 75 if he fishes immediately, and if one player fishes immediately, the best the other player can do is also to fish immediately, for otherwise he would get nothing.

This is an example of the classic „prisoner's dilemma“ game. But note that this outcome depends on the game being played only once. But fish stocks are renewable resources and thus allow for an indefinitely repeated game. In such a situation the outcome could be decidedly different. Specifically, if all players have been playing cooperatively in the past, they could agree, explicitly or tacitly, on continuing to do so, unless one of them begins to act non-cooperatively. Then, as soon as he is found out, the rest would in their own interest do exactly the same. Hence we may surmise that cooperation would be maintained if the outcome from cooperation would be better than deviating from cooperation and then suffer the retaliation of the other players. In present value terms, the payoffs from cooperation (V_c) and non-cooperation (V_n) would be, with r being the rate of interest and defection detected after one period:

$$V_c = \frac{75}{1+r} + \frac{75}{1+r^2} + \dots = \frac{75}{r}$$

$$V_n = 100 + \frac{50}{1+r} + \frac{50}{1+r^2} + \dots = 100 + \frac{50}{r}$$

$V_c > V_n$ implies that $r < 1$, that is, that the discount rate is less than 100%. But in the more general case of N countries sharing a stock with a growth rate of g , the expressions would be

$$V_c = \frac{100}{N} \frac{1+g}{1+r} + \frac{100}{N} \frac{1+g}{1+r^2} + \dots = \frac{100}{Nr} \frac{1+g}{1+r}$$

$$V_n = 100 + \frac{100}{N} \frac{1+g}{1+r} + \frac{100}{N} \frac{1+g}{1+r^2} + \dots = 100 + \frac{100}{Nr} \frac{1+g}{1+r}$$

and $V_c > V_n$ would imply that $r < g/N$. This is a revealing condition, even if it has been obtained with a very stylized model. It states that the growth rate of the fish divided by the number of countries should be higher than the discount rate. This has a simple, common sense explanation. Any fish left by a single country will grow at the rate of g , but if the stock is shared by N countries, the probability that the country actually sparing the fish will also catch it when it has grown bigger is $1/N$. Hence the expected return to any individual country from sparing the stock is only g/N , which then has to be compared to the return on turning the fish into money with certainty and saving the money in the bank. What this simple result puts into perspective is that the incentives for individual countries sharing a fish stock to save any fish for growth are quickly eroded as more countries are involved.

The zonal attachment principle

In our part of the world, the zonal attachment principle has been applied for dividing up shared fish stocks, most notably between Norway and the European Union. According to this principle, the total catch from a shared fish stock should be allocated among the countries involved on the basis of how much of the stock resides within each country's exclusive economic zone. The dividing-up of stocks on the basis of this principle has turned out to be quite robust. The most important exception probably is the

North Sea herring. When the zonal attachment was established in the early 1980s the herring stock had collapsed and was concentrated mainly in the EU-zone, only 4% resided in the Norwegian zone. Then, when the fishery was reopened in 1984, the EU offered Norway 4% of the total catch quota, in accordance with the zonal attachment established a few years earlier. Norway refused the offer and took whatever it wanted. The next time around, she was offered a sliding scale, depending on the size of the stock (25%, 29%, and 32%).

This underlines what already has been stated; any cooperative arrangement must offer each party an outcome which is at least as good as it can get on its own. In this particular case, the zonal attachment is not an immutable constant but depends on the size of the stock in question. The zonal attachment parameter was simply out of date. More generally the zonal attachment has to provide a solution that is at least as good as if the players each for itself decides to go it alone. There is no guarantee that the zonal attachment will do so. It is likely that small players would have to be offered a larger share of the total catch than corresponds to their zonal attachment parameter. The reason for this is the weak incentive a small player has for conserving fish. If only a small share k (< 0.5) of the stock is confined to the small player's zone and the fish move around freely, the probability that this particular player will reap the benefits of conserving the fish is only k and thus weak. At the same time the small player knows that the incentive for the large player to conserve the fish is much stronger, and if the fish move around freely the small player will gain from the big player's conservation effort. Both of these taken together imply that the small player must be offered a greater share than corresponds to his zonal attachment parameter.

The two accompanying figures illustrate the point. These are derived from a model where each of two countries decides how much to fish, given what the other party takes. The solution shows consistent solutions; i.e., such that what Player A expects Player B to take is in fact what Player B takes, and vice versa. The horizontal axis shows the major player's share of the stock, and the red line the share of the minor player. The blue line shows the minimum share of profits (total catch if costs and prices are the same for both) that the minor player must be offered if he is to accept the cooperative solution. We see that the minor player must, if he is small enough, be offered a share that is higher than the share of the stock in his zone. The difference between the two figures is that in the right hand one the costs per unit of fish caught depends on the size of stock. The stock migration model underlying these figures assumes that the growth of the stock from one period to the next depends on the total amount of fish that both parties leave after fishing, while the stock emerging after growth distributes itself in a given proportion between the two countries' zones irrespective of how large it is (constant zonal attachment).

Side payments

It can happen that some players in the fishery would be better off in the non-cooperative solution than they would be in the cooperative one without some extra inducements, often called side payments. This is illustrated in a paper by Ragnar Arnason and others.²⁴ The paper deals with the Norwegian spring spawning herring, which mainly occupies the Norwegian exclusive economic zone, but migrates into the economic zones of the European Union, the Faeroe Islands, Iceland, and Russia. Norway has a locational advantage; the distance between the fishing grounds and the ports in Norway is relatively short, and the stock spends most of the time in the Norwegian zone.

The table below shows the payoffs to various coalitions of the five players in this fishery; Norway, the European Union, the Faeroe Islands, Iceland, and Russia. As we can see, Norway gets a greater benefit in non-

²⁴ Ragnar Arnason, Gylfi Magnusson and Sveinn Agnarsson (2000): The Norwegian Spring Spawning Herring Fishery: A Stylized Game Model. *Marine Resource Economics* 15(4): 293-320.

cooperative solution (last row) than in the cooperative one (first row), for the reasons already mentioned. Therefore, Norway would have to be bribed into participating in the cooperative solution.

	Coalition	Norway	Iceland	Russia	Faeroes	EU	Total
1	Grand	2,701	2,583	2,645	2,607	2,069	12,605
2	NIRF_E	2,392	2,185	2,306	2,420	1,963	11,266
3	NIRE_F	935	1,554	1,125	613	1,171	5,399
4	NIFE_R	1,875	1,080	332	1,391	901	5,578
5	NRFE_I	1,633	360	1,370	1,249	961	5,572
6	RFEI_N	3,754	275	255	394	208	4,886
7	NIR_F_E	1,082	1,590	1,282	409	14	4,377
8	NIF_R_E	1,737	1,198	170	1,481	12	4,599
9	NIE_R_F	1,623	2,001	118	413	3	4,158
10	NRF_I_E	1,768	359	1,527	1,482	99	5,235
11	NRE_I_F	1,414	437	1,460	498	1,262	5,072
12	NFE_I_R	2,028	309	203	1,690	1,122	5,352
13	IRF_N_E	3,656	293	270	407	62	4,688
14	IRE_N_F	3,742	191	200	577	147	4,857
15	IFE_N_R	3,742	276	234	424	192	4,868
16	RFE_N_I	3,743	308	241	406	160	4,858
17	NI_R_F_E	1,623	2,001	118	413	3	4,157
18	NR_I_F_E	1,698	135	1,980	361	8	4,182
19	NF_I_R_E	2,117	148	156	1,949	4	4,374
20	NE_I_R_F	2,074	295	234	565	1,818	4,985
21	IR_N_F_E	3,408	71	120	373	4	3,976
22	IF_N_R_E	3,408	145	140	284	4	3,981
23	IE_N_R_F	3,742	184	234	564	121	4,845
24	RF_N_I_E	3,624	263	271	444	46	4,647
25	RE_N_I_F	3,743	295	167	564	72	4,841
26	FE_N_I_R	3,743	296	234	445	127	4,844
27	None	3,407	50	140	373	4	3,972

This example also illustrates the possibility that partial coalitions might arise in the absence of side payments. The first column in the table shows the coalition involved; for example, RFE_N_I means that Russia, the Faeroe

Islands and the European Union cooperate while Norway and Iceland act on their own. As we have seen, Norway would be better off on her own than in a grand coalition, and if we look at the coalitions of four (rows 2-6) we see that Norway would be the only country that benefits from breaking out of the grand coalition. But would a coalition of four endure? Looking at rows 13-16 we see that both the Faeroe Islands and Iceland would break out of a coalition of four (grand coalition less Norway). And would either of the coalitions of three endure? From Row 23 we see that Russia would gain from breaking out of a coalition with Iceland and the EU (Row 14), and from Row 25 we see that the Faeroe Islands would gain from breaking out of a coalition with Russia and the EU (Row 16). Neither of these two coalitions would break down further, as all coalition parties are better off than in the non-cooperative solution.

A country breaking out of the grand coalition (or some other larger coalition) would presumably realize that the breaking down of coalitions would not stop until either of these coalitions of two were left, so we have to go back and consider the pathways leading to these coalitions to see whether anyone has an incentive to start a process that ends up there. Norway was the one who broke out of the grand coalition, and she would be better off being outside either of these coalitions of two than in a grand coalition (Row 1 versus Rows 23 and 25). The coalition of four was broken by the Faeroe Islands or Iceland. If Iceland breaks out, we would end up with a coalition of Russia and the EU (Row 25), and Iceland would be better off in this situation than in a coalition of four (Row 6), so Iceland has an interest in breaking that coalition even when taking into account where it might all end. If the Faeroe Islands break the coalition of four we would end up with a coalition of Iceland and the EU (Row 23), which would be better for the Faeroe Islands than the coalition of four (Row 6), so the Faeroe Islands would also have an interest in breaking the coalition of four.

Changes in zonal attachment

Changed locations and migrations of fish stocks, as a result of climate change for example, could put the sharing agreements about fish stocks under strain. The Atlanto-Scandian herring is a good example. Before the crash in the late 1960s this stock used to migrate between Iceland and Norway and was fished in substantial quantities in what is now the Icelandic economic zone. There was even a local stock of spring-spawners at

Iceland, now apparently extinct. As a result of changed ocean climate and probably because of the crash of the stock as well this stock does not appear in the Icelandic economic zone to the same extent as it used to do. A sharing agreement based on the captures in the 1950s and 60s would no longer be credible, in case any such had ever been put in place.

To put this into perspective, consider a stock following the logistic law of growth so that the surplus growth function (G) is

$$G = aS \left(1 - \frac{S}{K}\right)$$

with $a = 1$ and $K = 1$ for simplicity. The present value (V) of catches, for a given initial stock of X_0 and a stock S left after fishing in every period is

$$V = X_0 - S + \frac{S(1-S)}{r}$$

implying an optimal $S = (1 - r)/2$. An annual interest rate of five percent gives the cooperative solution $S = 0.475$ and G (sustainable yield) = 0.25.

Suppose two countries share the stock and that it always distributes itself in given proportions α and $1-\alpha$ between the two countries' zones ahead of each fishing season, stays where it is during the season, and then breeds and grows as a unit before remerging the next fishing season. The present value of the fishery, ignoring costs and with a price equal to one for simplicity, is

$$V_i = X_{i0} - S_i + \frac{1}{r} \left[\alpha (S_i + S_{-i})^2 - (S_i + S_{-i}) - S_i \right]$$

for Player i , and vice versa for the other player ($-i$), with α replaced with $1-\alpha$. Maximizing V gives a non-cooperative solution for S_i :

$$S_i = \frac{2\alpha - r - 1}{2\alpha} - S_{-i}$$

and analogous for the other player, again with α replaced by $1-\alpha$. In this simple case, the minor player will not leave any fish in his zone, as he can count on the major player to do so in the latter's own interest. With $\alpha = 0.6$, the non-cooperative solution is $S_1 = 0.125$, $S_2 = 0$, $Y_1 = 0.0156$ and $Y_2 = 0.0938$. The minor player in fact catches much more fish than the major

player. This happens because the minor player knows that the major player will leave some fish behind in the latter's own interest, while any fish the minor player leaves behind will disproportionally benefit the major player. Hence the minor player leaves nothing behind, knowing he can count on some spillover from what the major player leaves behind and so emerges with a greater catch of fish.

To entice Player 2 to cooperate, he must catch as much fish in the cooperative solution as in the non-cooperative one. That is, his share of the cooperative catch (β) must satisfy $0.25\beta > 0.0938$, or $\beta > 0.376$. Zonal attachment (0.4) would be enough in this case. If we do this, the major player would get $0.6 \cdot 0.25 = 0.15$ and the minor player $0.4 \cdot 0.25 = 0.10$. The major player would get more of the benefit than the minor player.

If the zonal attachment changes to $\alpha = 0.7$ we would get $S_1 = 0.25$, $S_2 = 0$, $Y_1 = 0.0563$ and $Y_2 = 0.1313$ in the non-cooperative solution. Again the minor player would get a greater catch of fish. Now it would not be enough to offer the minor player a share equal to his zonal attachment parameter (0.3). The minimum share he would have to be offered would have to satisfy $0.25\beta > 0.1313$, or $\beta > 0.53$, in fact more than half of the sustainable yield and much more than his zonal attachment would indicate.

Now suppose that the stock migrates randomly and goes to one country's zone in each entirely, with equal probability. The expected present value of the catches for one country would be

$$V = X_0 - S + \frac{S}{2} \frac{1-S}{1+r} + \frac{S}{2} \frac{1-S}{(1+r)^2} + \dots = X_0 - S + \frac{S}{2r} \frac{1-S}{1+r}$$

as both countries may be expected to leave behind the same amount of fish every year. The optimal solution will now be $S = (1 - 2r)/2$ or 0.45, given the numbers we have used. Each country will now leave less behind and get a smaller catch, 0.2475 as against 0.25 before.

It would now be possible to achieve the fully optimal solution if the two countries have mutual access agreements to each other's zones and have agreed on how to divide the catch (presumably half and half, in this particular case).

Conclusion

Game theory is a useful tool to set out the basic requirements that a cooperative solution to the management of a shared fish stock must require. No country will accept cooperative management that gives it less than it could get in the absence of cooperation. We should be prepared for surprises such that countries with only a small share of a stock within their zone would not accept a deal that gives them catch quotas in proportion to their zonal attachment, and would not accept anything less than what may appear an inordinately large share of the total catch. This stems from the weak conservation incentives such countries have and the fact that they can be free riders on the conservation effort of larger countries.

Such conclusions as this are derived, however, from simple, stylized models. When modeling real world fisheries it is important to capture details that are of importance for the solutions. There could be circumstances conferring a disproportionate advantage on major player, such as the one illustrated with respect to Norway and other nations utilizing the Norwegian spring spawning herring. The migrations of fish stocks could also be a lot more complicated than in the stylized model above, and it could vary over time in ways that make it difficult to distinguish long, irregular cycles from trends and irreversible changes.

A market oriented management (MOM) model for straddling pelagic stocks

Torbjørn Trondsen. Norwegian College of Fishery Science, University of Tromsø, Norway.

Allocation of biological justified TACs means also allocation of potential resource rents as “super” rents compared to alternative investments. The presentation shows that Iceland may double the pelagic TAC landed values (from 135 to 290 mill €) if a Norwegian price level had been obtained. The difference in price levels rely mainly on the Norwegian landings of much more high priced products for direct human consumption compared to the Icelandic landings mainly to fish meal.

The variations in market values are influenced by the difference in the past industrial learning and the structural pressure from the quota allocation methods and available opportunities in the product markets. The

presentation demonstrates how lack of competition about the individual quotas and in the product markets tend to cement the structure in the industry to a limited or decreasing number even profitable incumbent firms which are volume and cost oriented but without strong motivation for improving the market oriented TAC values.

Recognizing that quota allocations in fact are allocation of resource rents and that the applied methods of allocation also are influencing the level of TAC value adding, the paper presents an auction allocation model of individual TAC shares (IQS -Individual quota shares)) with a motivation structure for extracting more value adding opportunities. The model define the interests of the member nations to be maximizing a resource rent royalty from their TAC share while the interests of the fishing enterprises are value adding catching and processing of individual quotas. The member nations may collect the net resource rent (royalty auction fee minus enforcement costs) according to an agreement about the relative ownership of the fish stock. All licensed fishing enterprises from the member states may be free to bid for individual quotas in the same royalty auction for catching in all fishing grounds in the straddling fish stock migration areas only limited by biological regulations of spawning grounds, juvenile environments etc. Such a management model opens up an international fish quota market controlled by the stakeholder nations of the straddling pelagic fish stocks. The model will motivate increasing TAC values without sacrificing sustainability or the relative stability of each country's ownership share of the fish stocks. With the potential to make more value adding of each tonnage of fish landings, the model might also make it easier to close a fish stock sharing deal between the stakeholder countries compared to the current dead lock situation where only quotas in tonnage counts on the negotiation table.

The model may also be adapted in allocation of part of the TAC, for example to the biggest vessels with technical capability to participate in all member states economic zones while the smallest coastal vessels keep a share of the national quotas.

Alternative approaches to sharing

Hjalti í Jákupsstovu, Faroe Islands.

From the migration triangle the important parts of the migration cycle is demonstrated. Viz -spawning area- nursery areas- feeding areas – wintering areas. It is argued that each area has its own value and should be treated as such. Using the distribution of the Norwegian Spring Spawning herring as an example trough more then 50 years it is shown how the distribution have changed with time and stock size and similarly the fisheries. However, the international instruments like UNFSA give some advise on how to approach the sharing of straddling stocks they give no formula to help the states in this process. In the presentation it is argued that a broader view than zonal attachment and historical fisheries should be adopted. Factors like dependency of the fisheries should be taken into account as well as availability of the stock to fisheries. Furthermore, scientific contribution to depict the stock size and distribution over the year is significant. Finally it is proposed that the states interested in the stocks of mackerel, blue whiting and Norwegian spring spawning herring should reshuffle the sharing and look at all three stocks in combination.

Final programme for the conference

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Nordic Council of Ministers

NORA
Nordic Atlantic Cooperation

MINISTRY OF FISHERIES

FINAL PROGRAMME

The conference is part of the activities undertaken by the Faroese chairmanship of the Nordic Fisheries Cooperation in 2010

Conference

The
Pelagic complex
in the **Northeast Atlantic Ocean**
Challenges and possibilities in the pelagic sector. Looking towards the future

Nordic House, Tórshavn, Faroe Islands
September 7th to 9th 2010

Ketild Andreassen

Get together reception
Monday 6 September – 18⁰⁰ hours

Session 1.
Tuesday 7 September 9⁰⁰ - 11¹⁵
Opening

Introduction	Hjalti í Jákupsstovu
Opening of Conference	Jacob Vestergaard , Minister of Fisheries, Faroes
Challenges in the pelagic sector: private sector perspectives	Chair Hjalti í Jákupsstovu
<p>The purpose of this session is to get a better understanding of the challenges that private operators in the pelagic fisheries sector face. Issues to be discussed cover the entire value chain, from harvesting, to processing and markets, and covering a wide geographic view. Key questions are:</p> <p>What are the future prospects of the pelagic sector?</p> <p>How should calls for more direct use of pelagic resources (as opposed to fishmeal and oil) be addressed?</p>	
Faroes	Bergur Poulsen , director P/F Havsbrún
Denmark	Christian Olsen , director Danish Pelagic Producer Organization
Iceland	Gunnþór Ingvason , Director Sildarvinnslan, Iceland
Norway	Audun Maråk , director, Norwegian Shipowners Association

Session 2.
Tuesday 7 September 11⁴⁵ - 17⁰⁰
Changes in the biological and hydrographical conditions for pelagic resources, including climate change. Chair: Eero Aro

<p>The objective of this session is to provide an up-to-date overview of the state of the pelagic resources in the North Atlantic. Often referred to as the pelagic complex, the session will focus on environmental conditions and their impacts on the distribution and productivity of pelagic species, including the effects of climatic change.</p>	
General distribution of Blue Whiting, Herring, Mackerel and Capelin	Asta Gudmundsdóttir , Senior scientist, Marine Research Institute, Iceland
Primary production in the Northeast Atlantic and the Nordic Seas	Trevor Platt , Executive director of POGO (Partnership for Observation of the Global Oceans)
Variation in hydrography, plankton productivity and fish distribution in the Northeast Atlantic	Hjalmar Hátún , Senior scientist, Faroe Marine Research Institute
Plankton Production in the Norwegian Sea	Webjørn Melle , Scientist, Institute of Marine Research, Norway
Can the Norwegian Sea accommodate three large pelagic stocks at the same time?	Jens Chr. Holst , Scientist, Institute of Marine Research, Norway
How will climate change effect the Northeast Atlantic and the Nordic Seas?	Bogi Hansen , Head of Section on Environment, Faroe Marine Research Institute
Climate change and fish distribution	Gregory Beugrand , Senior scientist, University of Lille, France
Challenges to the Russian pelagic fisheries	Alexander Krysov , Head of Pelagic Section at PINRO, Russia
Discussion	

Session 3.

Tuesday 7 September 11⁴⁰ - 17⁰⁰

Technological challenges for a more profitable pelagic fleet and industry – how to increase value and reduce costs.

Chair: **Ida Aursand**

The objectives of this session is to present and discuss the technological challenges facing the pelagic sector both at sea and on shore, and from this to identify future research priorities.

Vessel and gear design **John Willy Valdemarsen**. Institute of Marine Research, Norway

Carbon footprint and energy use of pelagic fish products **Erik Skontorp Hognes**. SINTEF, Norway

Onboard handling system, receiving and grading of pelagic fish **Leif Roger Gjølseth**. MMC TENDOS AS, Norway

Fuel technology and energy efficient design and control on pelagic vessels **Ingve Sørfoenn**. Wartsila

Is it sustainable to use fish as feed? **Ragnar L. Olsen**. Norwegian College of Fishery Science, University of Tromsø, Norway

Effect of catching methods and onboard handling systems on quality of pelagic fish **Ida Aursand**. SINTEF, Norway

Advanced chilling techniques for pelagic fish – full scale results **Sigurjón Arason**. Matis, Iceland

Potential fast non-destructive methods to measure fat in herring and herring products **Henrik Hauch Nielsen**. DTU, Denmark

Open discussion: The technical needs of the pelagic fish sector – fishing fleet and processing industry

Close of session 3

Evening reception sponsored by the Faroese pelagic sector

Session 4.

Wednesday 8 September 9⁰⁰ - 13³⁰

Economics and the management of the pelagic fleet. Chair: **Sveinn Agnarsson**

Economic considerations in the management of the pelagic fisheries are important to understand the overall outcomes, for fleets, fishers and for the public. Key issues include profitability and how the management framework and tools affect the economic outcomes and prospects for profit generation. Key questions to be covered include:

How can pelagic fisheries be made more profitable?

Does the present management arrangement produce economic profit?

In developing a modern fisheries model, what role does social aspects play?

Sum up from session 2 and 3

Session chairs

Resource profit in the pelagic fisheries

Max Nielsen. Associate Professor, Institute of Food and Resource Economics, Faculty of Life Sciences, University of Copenhagen

Lost rent, sunken billions

Ragnar Arnason. Professor, Department of Economics, University of Iceland

The financing of the pelagic fleet at the Faroe Islands

Bjarni Arnason. Auditor P/F NOTA, Faroe Islands

Socio-economics, Political dilemma?
Efficiency – social aspects

Poul Degnbo. Scientific adviser to EU

Panel discussion

**Afternoon
and evening:**

**Bus trip to Fuglafjørð
Conference dinner in Fuglafjørð**

Session 5.

Thursday 9 September 9⁰⁰ - 12³⁰

Allocation instruments for international shared stocks. Chair: Bjarti Thomsen

Joint resources have to be shared by the legitimate partners in a fair and acceptable way. The objective of this session is to present relevant methods and criteria in use and possible ways forward.

The economics of allocating resources on trans-boundary stocks

R. Quentin Grafton. Professor, The Australian National University

The (lack of) law on allocation of straddling and highly migratory stocks

A.L. (Andrew) Serdy. School of Law, University of Southampton, UK

Costal state arrangements. Blue Whiting, Herring, Mackerel, Capelin

Eskild Kirkegaard. Chief adviser on fisheries, DTU Aqua, Denmark

NEAFC management

Kjartan Hoydal. General Secretary of NEAFC

The Norway – Iceland experience

Áslaug Ásgeirsdóttir. Associate Professor of Politics. Bates College, USA

Questions – comments

Is game theory a possible method to solve the allocation problem?

Rögnvaldur Hannesson. Professor, NHH, Norwegian School of Economics and Business Administration, Norway

Alternative approaches to sharing

Torbjørn Trondsen. Professor, University of Tromsø

Alternative approaches to sharing

Hjalte i Jákupsstovu et al.

Session 6.

Thursday 9 September 14⁰⁰ - 16⁰⁰

Taking stock – the quagmire of allocation. Chair: Kjartan Hoydal

Debate: Based on issues raised in session 5 and brief remarks from key speakers, this session will explore the principles and practices of allocating shared fish stocks, addressing the question – are there more effective approaches?

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Nordic Council of Ministers

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The Pelagic Complex in the North East Atlantic Ocean

Challenges and possibilities in the pelagic sector
– looking towards the future

The Pelagic Complex conference was the major event in the Faroese Chairmanship of the Nordic Fisheries Cooperation 2010. The overall goal of the conference was to facilitate a scientifically-based and politically relevant discussion on the future of the pelagic fisheries in the North East Atlantic Ocean. This Proceedings presents an overview of the presentations and discussions that comprised the conference. The theme of the conference still remains politically contentious and the goal of creating a platform for joint dialogue on the future of the pelagic fisheries in the region is more relevant than ever and should serve as an excellent example for future activities designed to foster dialogue and renewed collaboration.